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(ENGLISH EDITION)

Competition by roads, waterways and airways.

(*Continuation*) (1).

France and Algeria.

FRANCE.

The following note received from the Managing Committee of the French Main-Line Railways relates to the steps taken by the Public Authorities and the Railway Companies during the second and third quarters of 1935.

General co-ordination measures.

The French Government during the second and third quarters of 1935 drew up and put into force a number of important regulations intended to form the charter of public transport in France.

I. — General co-ordination of the methods of transport.

A *decree of the 9th July 1935* set up, under the presidency of the Minister of Public Works, a Higher Transport Co-ordination Committee composed of important officials with a view to preparing a coherent transport policy in the general financial interest of the country, to examining all the questions outside the scope of the local bi-partite Co-ordination Committees set up or to be set up (Rail-Road, Rail-Water, Rail-Air) and to submitting to the Council of Ministers proposals in connection with this subject.

II. — Co-ordination of Railway and Road Transport.

1. *Passenger traffic.*

The decree of the 25th February 1935 has continued to be applied on normal lines. All the Departmental Technical Committees have been formed. At the end of September 1935, 23 of them had already come to unanimous agreements which have been submitted to the enquiry laid down by the above-mentioned decree. Nine other Technical Committees have forwarded to the Central Committee the papers relating to agreements which

(1) See *Bulletin of the International Railway Congress Association* since June 1934.

had not received the unanimous assent of their members or the approval of some dissenting road transport firms. All the papers relating to the departmental agreements were expected to be ready in time to be submitted to the General Councils at their Meeting in November last.

2. *Goods traffic.*

Clause 11 of the decree of the 19th April 1934, instituting the principle of Rail-Road Co-ordination, decreed that « all supplementary measures to ensure the co-ordination of railway and road transport would be the subject of a Public Administrative Regulation ».

We would remind readers that the first set of Regulations (decree of the 26th February 1935) dealt with the general organisation of co-ordination (Departmental Technical Committees) and of passenger traffic. These Regulations were reviewed in our last note (See November 1935 *Bulletin*).

A further Regulation (*decree of the 13th July 1935*) completed the first as far as goods traffic is concerned. This we will analyse later on.

Before this, however, a *decree of the 10th July 1935* laid down — the imposition of any new taxation having to be authorised by a law in France — that the Regulations in question could include the payment of *taxes to the Treasury* by road transport firms.

The arbitrator of the Rail and Road Co-ordination Committee was in fact in agreement with the four experts of the said Committee in recognising the utility of maintaining road goods transport services paralleling the railway services.

This recommendation, however, made in the interest of the road transport firms, is only compatible with the preservation of the public finances and the national interests if the motor transport firms have to pay taxes to the Treasury.

The public administrative Regulations (decree) of the *13th July 1935*, mentioned above, include actual co-ordination measures in connection with goods traffic, and also provide for a census of the motor vehicles used for goods transport and for their inspection in order to make it easier to see that the co-ordination agreements are carried out. The main provisions are summed up below.

a) *General provisions and definitions.*

First of all the decree extends the scope of the Departmental Technical Committees set up on the 26th February 1935 to public goods transport services.

Moreover, it defines the meaning of public goods transport. That transport is defined as « *private transport* », and consequently excluded from the decree, which is carried out by an individual or Company for their own requirements, to carry goods belonging to them or used in their business. by means of vehicles belonging to them or at their sole disposal for an uninterrupted period of at least three months.

That transport is also considered private which is carried out :

— by an Administration in connection with its services;

— by farmers, even in the case of transport on behalf of a third party, if this is not done for payment.

Any additional freight or paying return load takes the transport out of the « private » category and brings it under the classification of « public transport ».

Certain other classes of vehicles are not subjected to the provisions of this

decree, such as vehicles used exclusively for Post Office work, vehicles used for funerals, vehicles drawn by animals, etc.

All other transport is counted as public transport and classified under one of the following headings :

— *cartage services,* i.e. the transport of goods in urban districts and their suburbs;

— *general regular services,* offered to the public at advertised times, at least once a week, over given routes between given places. In particular express parcels services with an average speed exceeding 40 km. (25 miles) an hour, come under this section;

— special services for carrying *livestock;*

— special services for carrying *liquids in tanks;*

— special *removal services;*

— *other transport,* known as « on demand ».

b) *Census of vehicles used for public goods transport.*

The different classes of public goods transport being thus defined, the question arises as to the number of vehicles used for such purposes out of the 450 000 goods vehicles running in France. Heading 2 of the decree of the 13th July 1935 makes provision, therefore, for a census of lorries used for public goods transport.

This census will take place under the control of the Departmental Technical Committees and will be checked by issuing to each lorry used for public goods transport a public transport card or haulage service card, according to the case.

As from the 1st November 1935, no lorry used for public goods transport can work such transport without such a card without being penalised, and any transport other than that indicated on the said card is prohibited.

c) *Organisation of public goods transport.*

It would be impossible to give a detailed review of the rather minute organisation of public goods transport provided, and we must be content with the main features :

— The establishement in each Department, by agreement between the carriers, of a plan for the organisation of transport to remain in force until the 31st December 1941, on similar lines to that adopted in the case of passenger transport;

— Principle of compensation to road transport undertakings deprived of their present services;

— Preference given to road transport for short distances (maximum 50 km. = 31 miles) and to the railway for long distances (above 100 or 200 km. = 62 or 124 miles) with equitable distribution of average-distance transport between the carriers concerned. Three kinds of public transport cards are to be issued, according to which of the above classes of traffic the vehicle is engaged in, the classification by distance being in addition to that by kind of transport. The Departmental Technical Committee has to determine the precise limits of the transport zones, taking into special account the density of the railway system;

— Introduction of a tax on public goods motor transport, based on the number of tonne-kilometres. This tax in principle does not affect short-distance transport. The amount varies according to the distance, and it is the Departmental Technical Committee (or if unanimity is lacking, the Central Co-ordina-

tion Committee) which lays down for each transport undertaking the rate to be applied within the limits of the scale attached to the decree;

— The routes and timetables of public motor transport services are to be fixed in agreement with the railway so as to ensure the service being worked under the best conditions, particularly from the point of view of connections;

— The rates of public motor transport services are free from control within invariable maximum and minimum charges laid down for each line in the agreements;

— Finally the decree lays down the exceptional conditions under which the agreements can be revised.

d) *Various provisions.*

The decree imposes various obligations upon road carriers, in particular :

— Compulsory insurance against accidents to third parties, and also against risk of fire, and loss of, or damage to, the goods carried;

— A distinctive sign must be carried on vehicles used for public motor services;

— Annual inspection of the state of repair of the vehicle;

— Application of the eight-hour working day to the driving staff.

Finally the decree lays down the penalties, the basis of which is the temporary or permanent withdrawal of the public transport card.

III. — Co-ordination of rail and water transport.

1. *Regional agreements.*

The Minister of Public Works has sanctioned by ordinance two regional agreements between the railway and water transport undertakings relating to :

— navigation on the Rhône;

— transport of oil-yielding seed from Havre and Nantes to Château-Gontier.

2. *Inland navigation freights.*

As the agreements between the railway and navigation companies might be infringed by all the navigation undertakings, particularly in districts where large numbers of small boats are operated by their actual owners, it was necessary to begin by organising the water transport industry itself. This was the object of the decree of the 30th June 1934 already reviewed when dealing with the second quarter of 1934 (see *Bulletin*, March 1935, p. 271).

This decree relating to inland waterway freights was completed by the decree of the 31st May 1935 which lays down in particular :

— the information to be included in the Freight Agreements and the form of waybills;

— the organisation and working of the Freight Offices, the Public Freight Exchanges, and of a Shipping Agents' Professional Association;

— the conditions under which freight agreements are approved.

3. *Control measures for the co-ordination of rail and water transport.*

Finally, to check the way the regional agreements between rail and water transport are carried out, the *decree of the 29th August 1935* appointed to each of the seven regional co-ordination commissions a centralizing Chief Engineer whose duty it is to see the agreements are acted upon. For this purpose, all the water transport agreements have to

be endorsed before loading commences. This visa (provided for in the decree of the 31st May 1934 on freights) will only be granted provided the transport complies with the conventions in force. Likewise the agents must not complete any freight agreement until they have assured themselves that it does not infringe the provisions of the conventions in force.

A *decree of the 25th September 1935* laid down how the law shall be applied, particularly as regards the keeping of statistics, and nominated the Centralizing Chief Engineers.

IV. — Organisation of public air transport services.

A *decree of the 16th July 1935*, also applicable to Algeria, to the Colonies, Protectorates, and Mandated territories of France, makes the preliminary authorisation of the Government necessary before any regular public air services are set up.

V. — Tariff or other measures taken by the railways in favour of their clients.

Very important alterations have been made in the French railway rates, especially by the complete revision of :

— passenger rates;

— rates for consignments up to 1 000 kgr. (2 200 lb.);

— rates for livestock.

These measures which came into force during the 4th quarter of 1935 (the new passenger rates were applied as from the 1st October 1935) will be described in the next review.

* * *

ALGERIA.

The following note was received from the Management of the Algerian State Railways and Algerian lines of the Paris-Lyons & Mediterranean Railway.

Passengers.

In spite of the present severe crisis, the receipts for the first three quarters of 1935, thanks to the results given by the *reduced* sectional rates, show an increase of about 4 p. c.

The co-ordination of road and rail transport has entered upon an active phase. The first piece of work completed, the suppression of unnecessary road services and the co-ordination of others, has just been submitted to the public authorities for approval.

Goods.

On certain lines where competition from the road or coastwise navigation had succeeded in diverting much of the traffic, the application of all-in rates for door to door transport has already brought back an appreciable tonnage to the railway.

Rolling stock.

Two diesel railcars for metre-gauge lines and two trailers for these railcars are now under test.

[691 (.493) & 721. 9 (.493)]

Note on the fabrication of reinforced concrete parts on the Belgian National Railways,

by E. DESORGHER and S. SCHOTTE,

Engineers, Belgian National Railways Company.

In the February 1932 number of this *Bulletin*, Messrs. C. LEMAIRE, Ingénieur principal (1) and J. SCHOTTE, Ingénieur, published a note on the manufacture of reinforced concrete parts on the Belgian National Railways.

In its foreword, that note gave the reasons for setting up a special yard worked with company forces, and made clear the objects in view.

Continued efforts have resulted in extending the work to include new manufactures besides improving the production methods and consequently reducing the costs.

This supplementary note giving up-to-date results may be useful to technical officers having to manufacture reinforced concrete parts, prepare specifications, or supervise the fabrication of such parts in contractors' yards.

Production of the yard.

The work of the yard has increased considerably in the last few years as the following table shows :

	Materials used.				Concrete fabricated.
	Steel.	Cement.	Sand.	Stone.	Cubic metres.
	← Metric tons →				
1930	230	1 120	3 750	5 250	4 550
1931	328	2 686	4 958	6 812	6 203
1932	397	3 962	7 850	11 320	9 808
1933	448	4 524	9 377	11 608	11 665
1934	554	5 935	9 873	18 045	15 178

The reason for this activity is that permanent way parts were formerly made of wood and steel and the upkeep costs were heavy.

As parts of widely different character can be made in concrete economically, the further use of this material has received a strong impulse.

This development was accompanied by

(1) Mr. Lemaire, who was the originator of the scheme for the establishment of the yard, has since been appointed Chief Engineer, Permanent Way Department (Directeur de la voie).

the introduction of rational designs of the various details special to a railway. These designs were based on careful calculation and on the experience of concrete experts thoroughly conversant with railway requirements and the stresses set up in the parts both in regular use and during handling.

The final plans are bound up in the form of an illustrated album. Each part is shown with its number and approximate price. The album is issued to the construction staff who can get out their estimates quite easily with its help, and once the work is authorised the parts in concrete can be obtained by the simple issue of stores requisitions.

Now that the work has been developed to such an extent private firms may be expected to become interested in the supply of such stores, especially as there is no difficulty in drawing up the specifications and getting out the drawings.

The following parts are now used systematically on the Belgian Railways :

Fencing, solid or open work, or concrete posts with wire or trellis;

Posts of various kinds, such as level crossing posts with and without a St. Andrew's cross, posts for curves, down and up gradient posts, kilometre and hectometre posts, etc.;

Platform edgings (ordinary and raised);

Cable protection slabs and trunking for signalling transmissions, heating pipes, etc.;

Foundations of different kinds for signalling equipment;

Loading ramps, tranship platforms, coal yards;

Distant signal warning boards, etc.

Figures 1 to 4 show a few a these parts.

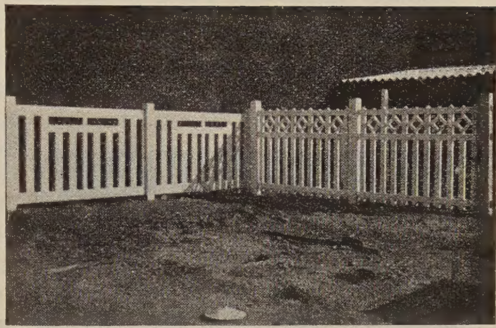


Fig. 1. — Open fencing.

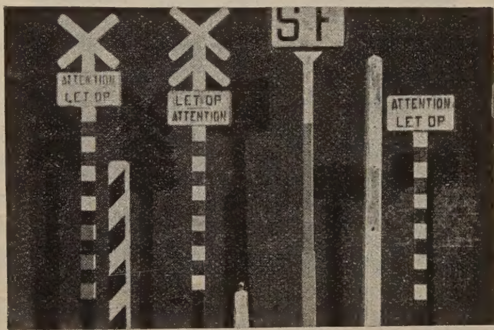


Fig. 2. — Various posts.

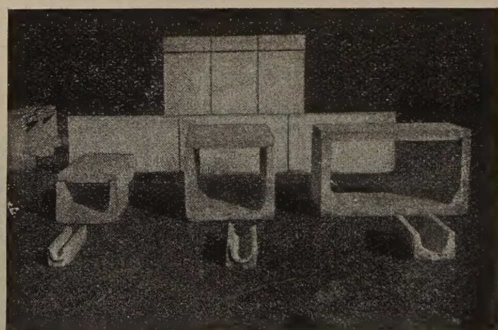


Fig. 3. — Ditch troughs, platform edges and cable protecting covers.

Amongst additional parts under consideration at the present time are :

Shelters, paving slabs for level cros-

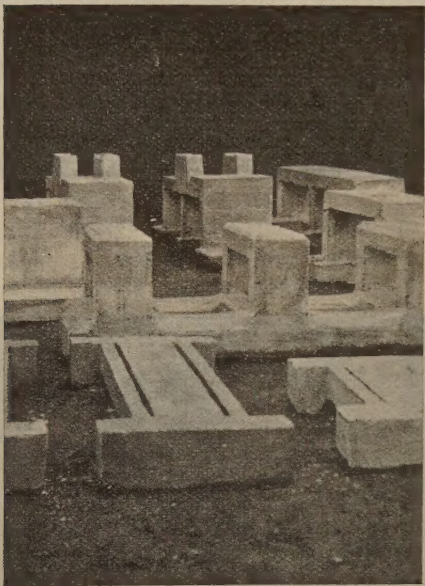


Fig. 4. — Signal equipment foundations.

sings, lamp standards, standard foundations for signals, etc. (figs. 5 to 7).

Fig. 5. — Foundations for signal pylons.

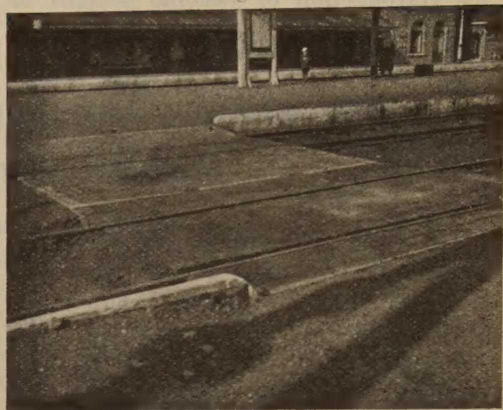


Fig. 6. — Level crossings.

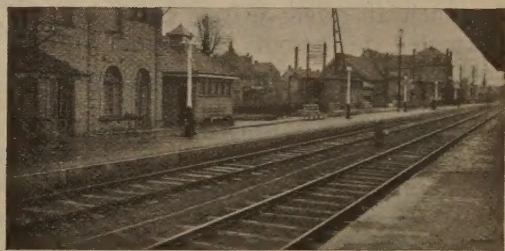


Fig. 7. — Lamp standards.

Raw materials.
Supply, quality and specifications.

Contracts for the raw materials are placed by open tender to cover about six months' requirements, the tenders, of course, being invited in good time. The specifications spread the deliveries over a certain period in quantities meeting manufacturing requirements.

The total value of the raw materials used is some 60 % of that of the concrete. The carriage charges included in the costs amount to 14 % thereof.

Sand. — The sand used at present is quarry sand from Brabant of 1.75 Abrams fineness. The specification requires that concrete made with the sand offered with the tenders, under the same conditions and of the same composition as the standard concrete, must have 105 % of the compression and tensile strength thereof (standard concrete is made with standard sand, which will pass through a screen of 64 meshes per cm^2 (425 meshes per sq. inch) and be held by 144 meshes per cm^2 (900 meshes per sq. inch) with the proportion, by weight, of 3 parts of sand to 1 of cement).

The Brabant sand in question gives 115 % of the tensile and 105 % of the compression strength of the standard concrete.

With the Rhine sand or Meuse sand of a 2.2 to 2.8 fineness, formerly used with excellent results, 20 % higher tensile, and 10 % higher compression strength than with ordinary concrete were obtained.

A curious feature is that when made by vibrating (as described below) concrete made with Brabant sand gives greater strength than when Rhine sand is used, all other conditions remaining equal. Each cubic metre of concrete contains about 500 litres of sand (Each cubic yard contains about 13.5 cu. feet = 84 Br. gallons of sand).

Stone. — The coarse aggregate used is crushed chips of porphyry, hard sandstone or slag, 5 to 10 mm. or 5 to 15 mm. (3/16 to 3/8 in. — 3/16 to 19/32 in.) size. The 5 to 10 mm. size is used in thin parts and the 5 to 15 mm. size in ordinary work.

The value of the sand and stone represents 36 % of the value of the materials used.

The stone content of the concrete is 900 litres = 1 180 kgr. per cubic metre (1 786 lb. per cubic yard).

Cement. — When placing contracts for ordinary cement, blast furnace cement is usually ordered, as the price is more favourable. The same specifications apply to such cement as to artificial Portland cement, namely :

Compression strength of standard concrete after	3 days :	200 kgr./cm²	(2 844 lb. per sq. inch).
» » » »	7 days :	300 kgr./cm²	(4 266 lb. per sq. inch).
» » » »	28 days :	400 kgr./cm²	(5 688 lb. per sq. inch).
Tensile strength of standard concrete after	3 days :	18 kgr./cm³	(256 lb. per sq. inch).
» » » »	7 days :	23 kgr./cm³	(327 lb. per sq. inch).
» » » »	28 days :	27 kgr./cm³	(384 lb. per sq. inch).

This cement is affected by low temperature which delays setting. To meet this disadvantage quick hardening Portland cement (P. A. D. R. super cement) is used with it during the Winter months, in proportions varying from 1/3 to 1/2 of the weight according to the temperature. Calcium chloride is also added, in the proportion of 4 % of the weight of water or about 1 kgr. (2.2 lb.) per sack of cement used. The P. A. D. R. super cement has to comply with the following specifications :

Compression strength of standard concrete after	1 day :	225 kgr./cm²	(3 200 lb. per sq. inch).
» » » »	3 days :	400 kgr./cm²	(5 688 lb. per sq. inch).
» » » »	7 days :	500 kgr./cm²	(7 110 lb. per sq. inch).
» » » »	28 days :	575 kgr./cm²	(9 174 lb. per sq. inch).

Tensile strength	of	standard	concrete	after 1 day :	20 kgr./cm²	(284 lb. per sq. inch).
»	»	»	»	3 days :	27 kgr./cm²	(384 lb. per sq. inch).
»	»	»	»	7 days :	30 kgr./cm²	(426 lb. per sq. inch).
»	»	»	»	28 days :	32 kgr./cm²	(455 lb. per sq. inch).

The cement is supplied in paper sacks, the use of which is now general.

The value of the cement represents 29 % of the materials. The concrete made in the yard contains 380 kgr. of cement per cubic metre (636 lb. per cubic yard).

Steel. — For the sake of standardisation ordinary parts in current manufacture have two types of reinforcement: 5 mm. (3/16 inch) diameter rods for distributing the load, and 8 mm. (5/10 inch) diameter bars for strength. Special parts which are sometimes ordered with specially calculated reinforcements, are made according to the drawings provided.

Ordinary mild steel is used and is delivered in sheeted wagons to protect it from rusting, in order to make it easier to build up the reinforcements by welding.

The value of the steel is 18.5 % of the total value of the materials used. The reinforcement weighs 40 kgr. per m³ (67.4 lb. per cubic yard) of concrete, which is very little.

The comparative qualities of the materials used in the concrete are discussed later on in dealing with the test results.

Manufacture and utilisation of the concrete.

The concrete is manufactured mechanically in revolving concrete mixers driven by petrol engines.

The work at the mixers and conveying the mixed concrete to the job in Decauville tipping wagons involves 2 working hours per cubic metre (1 1/2 hours per cubic yard) of concrete.

The materials are first of all mixed dry, after which the correct quantity of water is added.

Until recently the concrete was what is known as « plastic » with a shrinkage of 2 mm. (5/64 inch) under the slump test.

This concrete is easy to work into shape, and the fabricated parts have a pleasing aspect. A good deal of forms is required, however, for a large output, as it is dangerous to strip them before twenty-four hours. Then too, they must not be loaded on to a wagon before three weeks after being cast. This means the immobilisation of much capital and chokes up the yard.

The result of trying to find a concrete which would not get out of shape if taken immediately out of the form led, since 1933, to the use on a wide scale of the vibration processes which were beginning to be introduced into concrete manufacture, and restored to favour dry concrete of the consistency known as « terre humide » (moist earth).

Thanks to the small-amplitude vibrations to which the form is subjected, the concrete mixed very dry is tightly packed and becomes homogeneous throughout. This results in the moulded part being little liable to get out of shape, even if stripped at once, and the strength increases very quickly.

Jigging tables fitted with appropriate handling devices were found to be best suited to most of the makes of the con-

creting yard of the Belgian National Railways Company, in consideration of the dimensions and weights of the various parts manufactured therein.

Suitable vibrating plant, both electrically and pneumatically operated, are now on the market [1].

The first vibrating machines purchased have tables to take a load of 400 kgr. (880 lb.). The tables are vibrated by cams of small throw keyed on a horizontal shaft revolving at some 2 000 r. p. m. A vertical stop fixed under the tables rests on a ball-bearing crown which in turn is in contact with the cam. All the parts are enclosed in a well lubricated casing. The motion of the cam causes the vibration of the table.

The amplitude of the vibration can be set by the control levers provided.

The power required per table is 1.5 H.P. A single motor of appropriate power can drive a number of tables through belts.

These machines were found expensive to maintain. Parts including the ball-bearing rings frequently broke and the machines were out of action for a long time as a result.

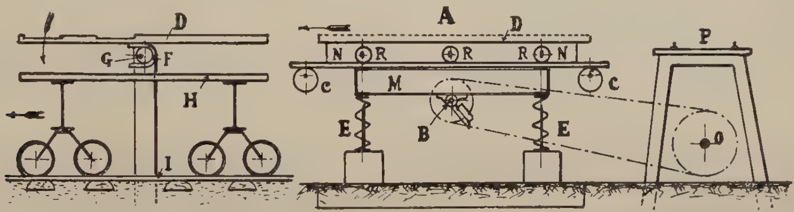


Fig. 8. — Diagram of a vibrating table carried on springs, with an arrangement for removing plane and heavy parts from the moulds.

Legend :

A. Vibrator on springs.
B. Vibrating shaft with eccentric weights.
C. Cams for raising the rollers.
E. Springs transmitting the vibration to the tables.
F. Turning-over hook attached to the moulds.
G. Shaft on which the mould is turned over.
H. Trucks with table for stripping.
I. Track.
M. U-bar framing forming the table.
N. Girder supporting the form.
O. Driving shaft and drive by belt and pulleys.
P. Decauville track for off-loading concrete.
D. Form (mould).
R. Set of rollers.

After much painstaking work, Mr. Van Hee, « Chef de section », has designed a very simple jigging table which is giving excellent results. The main features of this machine (fig. 8) are :

The table is in thick steel plate rive-

(1) For the history and study of vibrated concrete and the various vibration methods see :

— *Revue Universelle des Mines, de Métallurgie et des Travaux publics* (5th July 1934). Editor, 12, rue P. Van Hougaerde, Liége.

Paul Prax, Ingénieur A. I. G. : « Application de la vibration à la mise en place du béton entre coffrages » (Use of vibration when ramming concrete between shutterings).

— *La Technique des Travaux* (September 1934). Editor, 196, rue Grétry, Liége.

J. Bollomey : « Le béton vibré ou pervibré, ses propriétés et conditions d'emploi » (Vibrated or pervibrated concrete, its properties and conditions of use).

— *Bulletin technique de l'Association des Ing. sortis de l'Université de Bruxelles*, No. 7, 1934. Editor : University of Brussels, 50, avenue des Nations.

L. Ardouillie : « Le Béton vibré » (Vibrated concrete).

— *Bulletin mensuel de la Société des Ingénieurs civils de France* (May-June 1930), rue Blanche, 19, Paris.

M. Trèves : « Le béton vibré et pervibré » (Vibrated and pervibrated concrete).

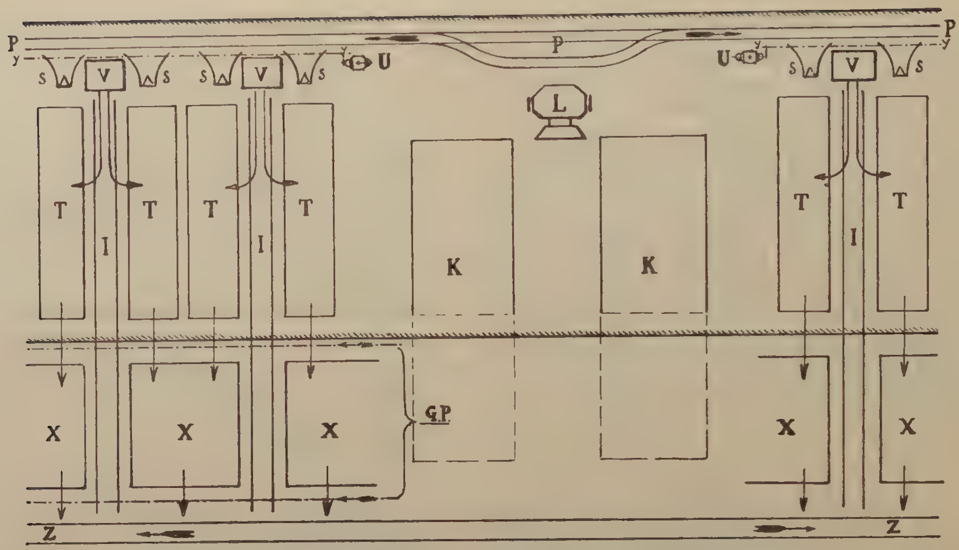


Fig. 9. — Diagrammatic layout of concreting yard.

Legend :

Limit of covered-in parts.
P. P. Decauville track for distributing concrete.
S. Concrete bins.
V. Vibrators.
I. I. Track for tipping trucks.
T. Stock ground for first hardening.
X. Stock ground.
Z. Z. Loading and unloading road with exit at both ends.
G. P. Gantry crane track.
K. Stock of raw materials.
L. Concrete mixer.
U. Electric motors driving vibrators.
y. y. Transmission gear of vibrators.

Note. — The yard in which the work is done by hand is laid out in the same way. The areas T are the fabrication areas. The forge, reinforcement shop, and joiners' shop are arranged at one end of the yard.

Fig. 10. — Fence panels stacked in the area in which they are left during the first hardening stage.

ted to a well cross-stayed frame of U bars. These U bars are carried on four springs E with steel guides either embedded in a concrete foundation or carried on a 4-wheeled truck according to whether the machine is stationary or mobile. A driving shaft B running in two ball bearings is fastened to the U bars carrying the table. This shaft carries one or two eccentric cams and is driven through a flexible coupling by a lay shaft in line with it, carried in two plummer blocks quite independent of the table. The main shaft O drives the lay shaft by pulleys and belt. As soon as it moves it drives the vibrator shaft. The eccentric masses on this shaft set up centrifugal forces which set up vibrations transmitted through the four springs. The delicate part was the flexible coupling; an ordinary spring was found quite satisfactory. This machine is both flexible and sturdy, all the load of the shocks being taken by the springs. Large masses of concrete can be vibrated with it. The amplitude of the vibration varies as the speed of the motor, which is controlled by a rheostat.

There are available other designs of vibrating tables without springs. Usually a motor is fitted and drives an eccentric weight. This special motor is running all the time under shock; therefore it is not working under the best of conditions.

Work done at the vibrating tables must be carefully considered in order to reduce the labour charges to the minimum.

Diagram 9 shows the lay-out of a yard fitted with such vibrating machines.

The vibrating machines V are installed in a line alongside a Decauville track P, which is 1 m. (3 ft. 3 3/8 in.) above the level of the vibrating yard. The Decauville wagons are moved mechanically. Beside each machine two troughs S are provided into which the freshly mixed concrete is poured. At each vibrating machine a short length of track is put down, on which small trucks run.

Figure 8 shows the lay-out of the trucks, which have joists fitted to them. The newly fabricated parts after being removed from the forms on one of the bottom boards are slid on these joists which are kept well oiled for the purpose. When the parts are too heavy or too fragile to be handled at once, they are left in the forms two days; the trucks have then sufficient capacity to meet the case. Some parts, such as those of little height, and blocks, are removed immediately and are stocked on the flat in the first hardening area T, figure 10. After a few days hardening they are stood upright or stacked to save room in the stock yard X alongside the loading road (fig. 11).

The parts are made very readily in the vibrating machines; the reinforcement is centred in the form and the men then shovel in the concrete (fig. 12). The form is then vibrated long enough to make the mass of concrete uniform, which is indicated by the cement rising over the surface of the concrete. The surface is then smoothed off with a plastering trowel.

Special attention has to be given to the way the parts are taken out of the form. When the still full form can be lifted by two men the part can be stripped out easily by turning it over onto one of the base boards. If however, as is frequently the case, the parts are too heavy to be man-handled, means have to be devised for tipping without lifting.

In the case of some very heavy poles we provided inclined planes in front

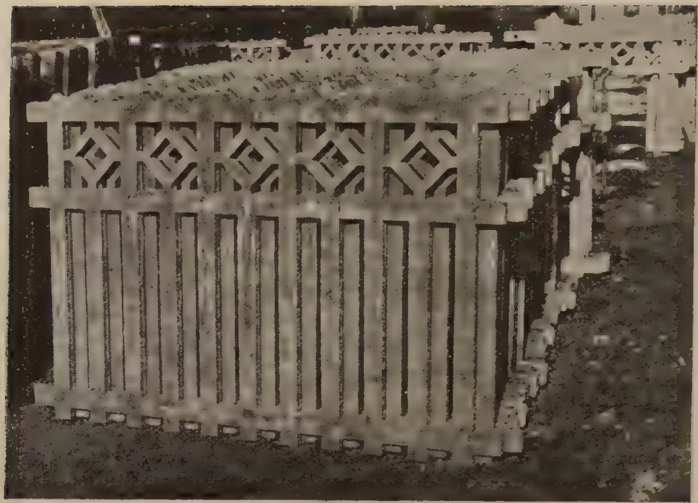


Fig. 11. — Fence panels in the stock ground.

of the vibrating machines; the men slide the moulded part onto them and are able to turn it over easily. Fencing sections are easily stripped thanks to the arrangement shown in figure 8, which includes the rollers R mounted on the vibrator, and which can be raised by two cams C to take the form D containing the manufactured part that is lifted off the vibrator. The form can be pushed on to these rollers; it carries two hooks F fastened on their axis of equilibrium. These hooks, after the mould is moved, grip the shaft G about which the parts are tipped and turned. The shaft G can be lifted slightly by two levers so that the part can be stripped when resting on the floor H of the truck specially brought into position for this purpose.

It should be noted that every form containing a newly made part can be completely turned over without the part falling out; actually the forms must be tapped to release the part from the form.

In the case of other bulky parts, differential pulley blocks are used to lift and turn them.

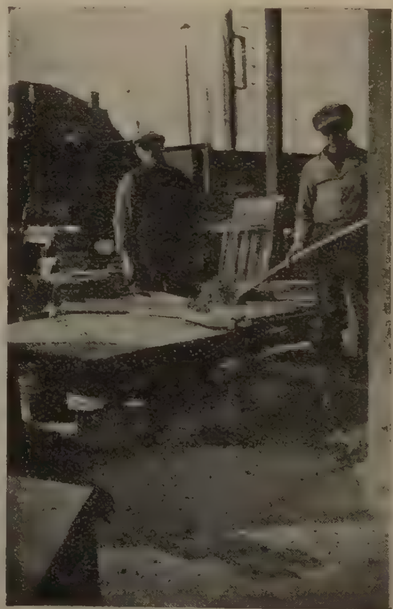


Fig. 12. — Vibrating table in action.

Manufacture and use of the reinforcement.

Before using the vibration process at Roulers metal forms were little used. The number of forms needed for mass production was so great as to make the cost prohibitive and in many cases out of proportion with the object in view.

With the vibration process a large production is possible from a single form or a small number of forms, as it is possible to strip the parts immediately. Wood forms cannot be used as they are neither tight nor rigid enough. The metal mould, though dearer, does not get out of shape, lasts indefinitely and requires no upkeep. Then too the parts made in them are all exactly the same.

Metal forms are being substituted systematically for the old wood forms. Wood forms will be retained for new details the final shape of which is not yet fixed and for parts few of which are wanted or which are too complicated.

The metal forms suitable for vibrating machines have to be designed to facilitate removing the part by turning over. The design consequently differs in many cases from that of forms used for parts made from plastic concrete. In some cases too the shape of the parts has had to be altered slightly. During production certain improvements are sometimes found necessary and these can be made in the yard workshop. This shop contains a welding plant and a number of machine tools.

Details of forms are given in figures 13 and 14 and the following should be noted :

1. (fig. 13) : for platform edging, the independent lower pressed plate C giving the outside contour of the part; these plates are required whenever the lower face is profiled;

2. (fig. 14) : the blocks A on which the form rests after being turned over. As a rule the part, in spite of the form being well oiled, sticks in it and these

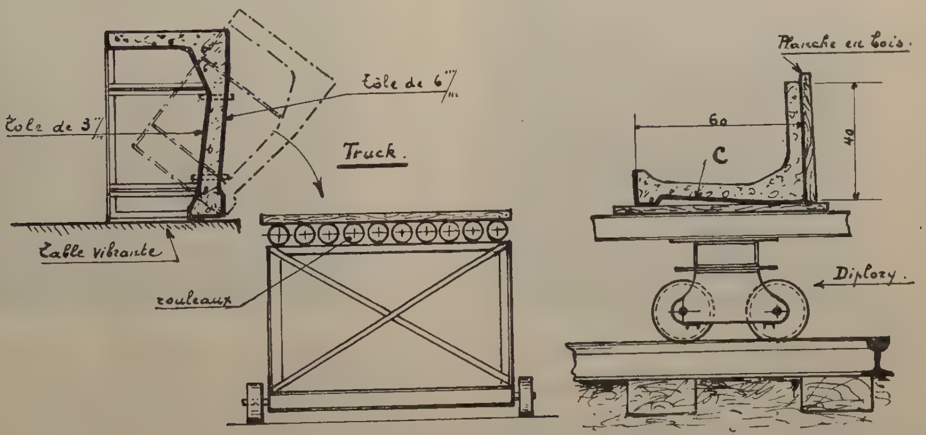


Fig. 13. — Mould for ordinary platform edge.

Explanation of French terms:

Tôle de 3 m/m (6 m/m) = 1/8 in. (1/4 in.) plate. — Planche en bois = wood plank. — Diplory = small truck. — Table vibrante = vibrating table. — Rouleaux = rollers.

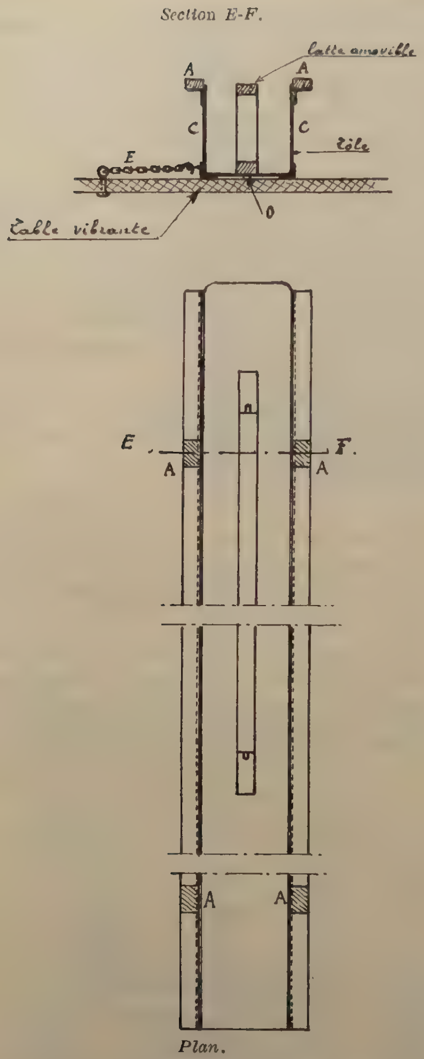


Fig. 14. — Mould for lightened-out fencing post.

Note: Latte amovible = detachable board. — Table vibrante = vibrating table. — Tôle = plate.

blocks make it possible to loosen the part by tapping the form without having to shake it when lifting it;

3. the plates C extend a little beyond the horizontal flange of the stiffening angle and this facilitates finishing off during manufacture;

4. The ventilating holes O in the bottom of the mould; air gets in through these holes when the part is being removed and in conjunction with the oiling of the inner faces prevents the concrete from adhering to the forms;

5. the two light chains E secure the form to the vibrator during fabrication.

Making and placing reinforcements.

The reinforcement, except for bending, is prepared on mass-production lines in a specially laid out shop (fig. 15).

The bars, of commercial length, are successively stocked, sorted by diameters and lengths, cut to standard lengths, and possibly hooked at the ends and assembled into mats of various dimensions.

These mats are returned to stock until wanted on the job.

The bars are cut to length mechanically.

The machines in the reinforcement shop are provided with suitable benches.

The bars in a reinforcement are assembled by welding.

220/50-volt spot resistance welding machines are used so that no metal is added. These devices are fitted with automatic cut-outs and have the following characteristics (fig. 16) :

Maximum power : 15 kw.

Useful length of arm 550 mm. (21 9/16 inches).

The welding is facilitated by the use of templates with guiding notches, so located that the workman has merely to put the bars into place to get the squaring required.

The welded reinforcement is cheap, very rigid, and much better finished than when bound.

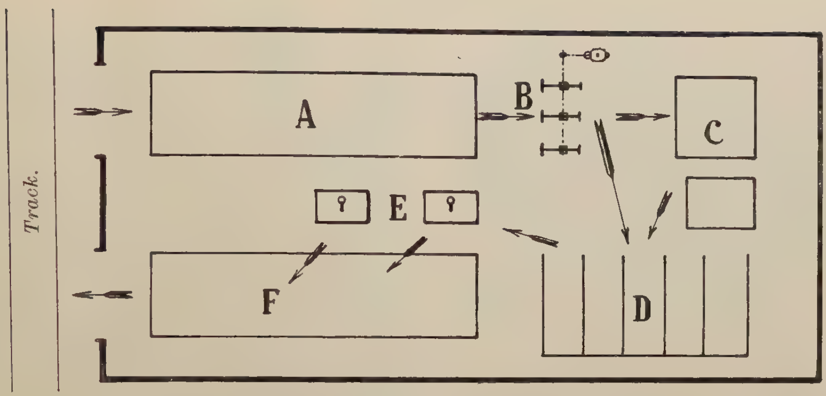


Fig. 15. — Steel shop. Diagram.

A. Stock of bars.
B. Electric shears and gauges.
C. Table with bending gauges.
D. Stock bins for partly finished iron work.
E. Spot welding with working benches.
F. Stock of finished reinforcements.

Fig. 16. — Welding reinforcements.

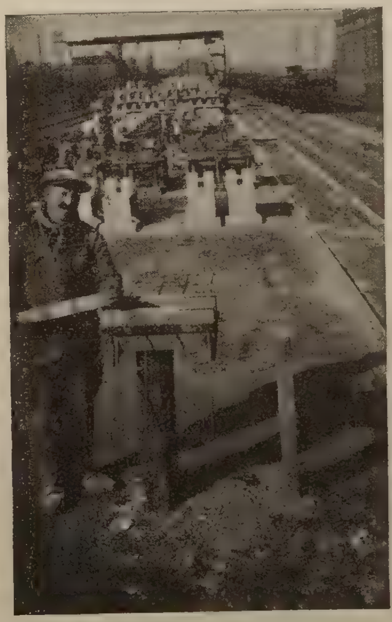


Fig. 17. — Block for bending reinforcing wire.

The reinforcement usually leaves the shop as flat grids.

The reinforcement is bent to the drawing dimensions easily and quickly in the concreting yard before it is put in the moulds, in blocks specially designed for each part by Mr. Van Hée, « Chef de section ».

Figure 17 shows one of these blocks.

Cutting off, hooking the bar ends, and bending the reinforcement absorbs about 6 hours labour per ton, the welding 24 hours, so that the finished reinforcement requires some 30 hours per ton. These figures would be less in the case of large-diameter bars. One welder can make 1 000 to 2 000 spot welds per hour.

Tests of concretes.

The use of vibrated concrete is relatively recent and few results have been published so far.

A series of tests are carried out periodically in the Roulers yard with the following, amongst other, objects :

Comparison between vibrated, rammed, and plastic concrete; comparison between the various inert materials of Belgian origin; the determination of the best proportions of inert materials, cement and water to produce the cheapest concrete with sufficient strength for the particular part being made; comparative strength of various kinds of concrete, vibrated during different periods, etc.

The conclusions of these tests are based on the value of the different characteristics of these concretes, after 28 days' exposure to the air, namely :

a) *Their composition.* The quantity (weight) of concrete to fill approximately a set of three moulds is determined by preliminary tests. The proportion of all ingredients is fixed by weight; the proportions by apparent volume of the sand and coarse aggregate are calculated from their specific apparent weight, i.e. after determining the weight of the unit volume levelled off in the measure without being rammed. These specific volumes of the same material vary with the modulus of fineness and the degree of humidity. As an example let us take a weight of concrete intended to fill three cubes of a total volume of :

$3 \times 0.20 \times 0.20 \times 0.20 = 0.024$ m³ (0.847 cu. foot), and composed of :

Cement	9.250 kgr.	(20.39 lb.).
Sand	13.750 kgr.	(30.31 lb.).
Stone	34.500 kgr.	(76.06 lb.).
Water	4.100 kgr.	(9.04 lb.).
Total weight . . .	61.600 kgr.	(135.80 lb.).

Weight of concrete left over after moulds are filled	4.35 kgr. (9.59 lb.).
Weight of fresh concrete contained in the moulds	61.60 kgr. — 4.35 kgr. = 57.25 kgr. (126.21 lb.).
Weight of the concrete cubes after stripping.	56.56 kgr. (124.69 lb.).
Water lost after setting, i.e. 1.2 % of the weight of the concrete	0.69 kgr. (1.52 lb.).
Total weight of the concrete (less weight of water lost after setting) 56.56 + (4.35 — 1.2 %) = 60.86 kgr. (134.17 lb.) .	

From this we get :

Weight of cement : $\dfrac{9.25 \times 56.56}{60.86 \times 0.024} = 357.89$ kgr./m³ (603.24 lb. per cubic yard).

Weight of sand : $\dfrac{13.75 \times 56.56}{60.86 \times 0.024} = 532$ kgr./m³ (896.68 lb. per cubic yard).

Apparent volume of sand : $\dfrac{532}{1.35} = 394$ litres (10.63 cu. feet).

Weight of stone : $\dfrac{35.500 \times 56.56}{60.86 \times 0.024} = 1334.83$ kgr./m³ (2249.85 lb. per cubic yard).

Apparent volume of stone : $\dfrac{1334.83}{1.31} = 1023$ litres (27.62 cu. feet).

Weight of water : $\dfrac{4,100 \times 57.25}{61.60 \times 0.024} = 159.00$ kgr./m³ (268 lb. per cubic yard).

b) Their *specific weight* obtained by dividing the weight of the test pieces by their volume (metric units);

c) *Compression strength* found by crushing sets of 3 cubes of 20 cm. (7 7/8 inches) sides made in wood moulds with planed steel plate divisions; very smooth regular surfaces are obtained with these plates and there is no danger of local crushing by the test machine heads.

d) Their *tensile strength* measured by the bending of three prismatic bars of 44 cm. $\times$ 10 cm. $\times$ 10 cm. (17 5/16 in. $\times$ 3 15/16 in. $\times$ 3 15/16 in.) on supports 10 cm. (3 15/16 in.) apart, loaded at the middle. Concrete is not perfectly homogeneous and there may be local defects in it. The variable value of the tensile strength obtained by the formula $R = \dfrac{MV}{I}$ is therefore only quite approximate. The results obtained by these tests, therefore, are less conclusive than those from the compression tests.

e) Their *relative compactness*, defined by the proportion of the volume of the voids between the coarse aggregate occupied by the cement embedding it under the hypothesis that the mixing water causes no increase in volume.

For example, 1 cubic metre of concrete composed of :

1 353 kgr. of stone of a density of . 2.65.
529 kgr. of stone of a density of . 2.61.
363 kgr. of stone of a density of . 3.1.

1. Absolute volume of stone . . . . $\dfrac{1353}{2650} = 0,5104$ m³.

2. Absolute volume of sand . . . . $\dfrac{529}{2650} = 0.2033$ m³.

3. Absolute volume of cement . . . . . . $\dfrac{363}{3100} = 0.1171$ m³.

Total 2. + 3. = 0.3204 m³.

Volume between the stones :

$$1 - 0.5704 = 0.4896 \text{ m}^3.$$

Compactness of the concrete :

$$\frac{0.3204}{0.4896} = 0.654$$

Various precautions are always taken to make sure the tests are accurate.

The materials used are all dried so as to make it possible to ascertain the exact volume of mixing water and the weight of the materials used.

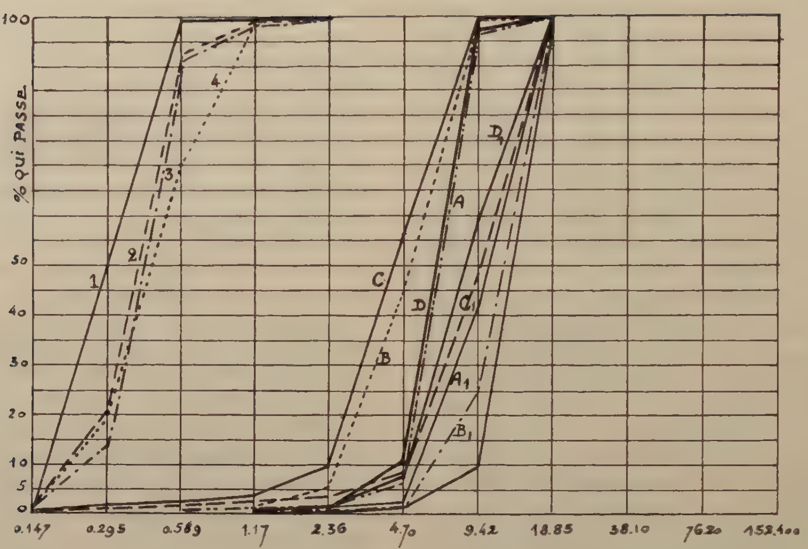
The water used is gauged in graduated containers.

The materials are weighed in an automatic machine, with graduated dial, weighing up to 50 kgr. (110 lb.) to within 20 gr. (0.7 ounce).

The cement is taken from a heap made with the contents of several sacks : the heap is well turned over so as to make the cement as uniform as possible.

The mixture is prepared by turning the materials over very thoroughly, first of all dry, to get a very uniform mixture, and then whilst adding water.

The fineness of all the raw materials is measured by ten sieves of the Abrams series. Figure 18 gives the granulome-



Opening of screen in millimetres.

Fig. 18. — Granulometric diagram.

1. Sea sand.	A = Porphyry (3/16 in. to 3/8 in.).	C = Crushed slag (3/16 in. to 3/8 in.)
2. Mont-St-Guibert sand.	A_1 = Do. (3/16 in. to 5/8 in.).	C_1 = Do. (3/16 in. to 5/8 in.)
3. Moll sand.	B = Hard sandstone (3/16 in. to 3/8 in.).	D = Rhine gravel (3/16 in. to 3/8 in.)
4. Rhine sand.	B_1 = Do. (3/16 in. to 5/8 in.).	D_1 = Do. (3/16 in. to 5/8 in.)

Note: % qui passe = percentage getting through screen.

tric diagrams of the various materials tested in the yard.

A series of average results so far obtained is given in the tables and commented upon.

Comparison between concretes of similar composition as regards dry materials (Table I).

The compression strength of vibrated concrete is 20 % higher than that of rammed concrete and 60 % higher than that of plastic concrete. The difference is less in tension. Concrete No. 3 is still too dry for ordinary use; No. 5 which corresponds to some 7 cm. (2 3/4 inches) slump under the Abrams cone is the only one that can be used for thin parts made by hand .

The compactness and specific weight of the concrete vary in the same way as the strength.

The lower compactness of plastic concretes is obviously due to the excess water which, after evaporation, leaves voids causing a reduction in strength.

During the tests it was found that as a rule vibrated concretes gave uniform results between test cubes, whereas those obtained with rammed and plastic concrete varied a good deal. Vibration therefore automatically gives concrete of good quality whereas with the others the influence of the workmen is greater.

Number of concrete.	P. A. D. R. cement.	Concrete mixtures. — Proportions per cubic yard. Sand. Origin.	Modulus of fineness.	Volume.	Coarse aggregate (stone). Origin and dimensions.	Volume.	Water. Volume.	C/W	After 28 days. Specific weight of concrete.	Compression strength.	Tensile strength.	Compactness.
	lb.			*Cu.feet.*		*Cu.feet.*	*Br. gall.*	*(weight).*	*Lb./cu.yard.*	*Lb./sq.inch.*	*Lb./sq.inch.*	
					Vibrated concrete.							
1	611	Mt. St.-Guibert.	1.84	10.77	Porph. 3/16"-3/8"	28.00	28.4	2.15	3 991	5 860	...	0.646
2	606	Do.	Do.	11.31	Do.	27.81	28.3	2.14	4 023	5 931	755	0.645
					Rammed concrete.							
3	626	Do.	Do.	11.04	Do.	26.59	33.8	1.85	3 938	5 106	...	0.638
					Plastic concrete.							
4	602	Do.	Do.	11.37	Do.	25.95	38.9	1.55	3 909	4 110	525	0.605
5	572	Do.	Do.	10.38	Do.	24.68	44.7	1.28	3 808	2 688	461	0.551

Tests of vibrated concretes.

Comparison of the value of coarse aggregrates of different kinds (Table II).

This table shows that porphyry and hard sandstone (grès) have much the same qualities, that crushed slag is by far the best material and that river gravel (pebbles) is the worst both in tension and in compression. This was expected from former tests. The roughness of stone and especially broken slag, compared with the smooth surface of river gravel, means better adhesion which affects the strength. The pozzolanic qualities of slag make it better than any other inert material.

Comparison between coarse aggregates of different sizes (Table II).

Small crushed stone as a rule gives slightly better concrete. With large stone, the concrete is less homogeneous. Concrete made with small stone is more easily worked into thin parts.

Aggregates made of stone of different sizes to improve the granulometric factor have not given much greater strength.

The granulometric diagrams of these concretes (fig. 19) generally show too low a percentage of elements between 0.5 mm. and 5 mm. (5/256 in. and 3/16 in.). The diagram for concrete from 5 to 10 mm. (3/16 in. to 3/8 in.) slag is the most consistent.

A further series of tests are to be made with varying quantities of stone up to 5 mm. (3/16 in.) size.

Comparison of the values of different sands (Table III).

Quarry sand gives as good results in vibrated concrete as Rhine sand although the latter is much coarser. Vibrated concrete made of sea sand which is

TABLE II.

Number of concrete.	P. A. D. R. cement.	Concrete mixtures. — Proportions per cubic yard. Sand. Origin.	Sand. Modulus of fineness.	Sand. Volume.	Coarse aggregate (stone). Origin and dimensions.	Coarse aggregate (stone). Volume.	Water. Volume.	C/W	After 28 days. Specific weight of concrete.	After 28 days. Compression strength.	After 28 days. Tensile strength.	Compactness.
	Lb.			*Cu. feet.*		*Cu. feet.*	*Br. gall.*	*(weight).*	*Lb./cu.yard.*	*Lb./sq.inch.*	*Lb./sq.inch*	
1	611	Mt.-St.-Guibert.	1.84	10.77	Porphyry 3/16" - 3/8"	28.00	28.4	2.15	3 991	5 860	...	0.646
2	619	Do.	Do.	10.96	Do. 3/16" - 5/8"	27.89	28.1	2.20	4 054	5 760	715	0.675
3	614	Do.	Do.	10.83	Do. { 3/16" - 3/8" 3/16" - 5/8"	9.37 18.41 }	27.8	2.21	4 012	5 476	...	0.622
4	612	Do.	Do.	10.83	Do. { 3/16" - 3/8" 3/16" - 5/8"	18.71 9.21 }	28.1	2.18	4 025	5 902	...	0.675
5	595	Do.	Do.	10.53	Hard sandstone 3/16" - 3/8"	27.30	27.8	2.15	3 892	6 116	905	0.635
6	607	Do.	Do.	10.72	Do. 3/16" - 5/8"	27.30	27.6	2.20	3 970	5 789	801	0.661
7	607	Do.	Do.	10.75	Do. { 3/16" - 3/8" 3/16" - 5/8"	9.29 18.23 }	27.6	2.20	3 978	5 974	...	0.661
8	600	Do.	Do.	10.61	Do. { 3/16" - 3/8" 3/16" - 5/8"	18.36 9.02 }	27.8	2.16	3 938	5 974	...	0.647
9	612	Do.	Do.	10.83	Slag 3/16" - 3/8"	28.11	28.9	2.10	4 027	6 998	8 648	0.647
10	617	Do.	Do.	10.90	Do. 3/16" - 5/8"	27.81	28.8	2.15	4 045	6 926	951	0.658
11	617	Do.	Do.	10.90	Do. { 3/16" - 3/8" 3/16" - 5/8"	9.42 18.52 }	28.9	2.13	4 050	7 112	...	0.657
12	619	Do.	Do.	10.94	Do. { 3/16" - 3/8" 3/16" - 5/8"	18 93 9.29 }	29.3	2.12	4 062	6 898	...	0.661
13	602	Do.	Do.	10.63	Round gravel 3/16" - 3/8"	27.62	26.7	2.25	3 932	5 576	711	0.650
14	360	Do.	Do.	10.69	Do. 3/16" - 5/8"	27.27	26.2	2.31	3 960	5 789	6 784	0.657

are lost; a further 20 litres (3.36 Br. gallons) are lost during the 28 days' hardening.

Proportions of cement (Table VI).

The strength of vibrated concrete increases almost in direct proportion to the amount of cement used provided the percentage of mixing water varies only slightly, so that the plasticity remains constant and the concrete is easily worked up. The results of many tests have shown that in practice the $\frac{\text{cement}}{\text{water}}$ ratio cannot be held constant in vibrated concrete so as to be sure of getting great strength. If this is attempted, the concrete is too dry and liable to disintegrate when the proportion of cement is low, and too fluid when the cement content is high.

The unfavourable effect of the constancy $\frac{C}{W}$ factor on the strength of the concrete is shown by comparing the concretes Nos. 3, 4 and 7.

Comparative tests of two kinds of concrete, some of them containing P.A.N. cement, and the others blast furnace cement in the same proportions, show that these ingredients are of equal quality. The addition of small quantites of lime to these cements gave varying results and no definite increase in strength could be claimed for the practice.

Vibration time. — The vibration has to be continued long enough to ensure the mass of concrete becomes thoroughly homogeneous. The tests seem to point to 4 minutes as the best time. Concrete vibrated for a shorter period shows a lower strength. If vibrated for only 1 to 2 minutes more the strength increases only very slightly. Further tests will be made to see if a long period of vibration does not in the end result in the materials desintegrating.

Immersion. — Spraying. — Tests show that the strength can be increased 10 % if the parts are immersed in water. Parts sprayed with water or allowed to remain in the open are stronger than those kept indoors in too dry an atmosphere.

Hardness. — The tests fail to show any connection between the hardness and resistance to wear of concretes and their tensile or compression strength. Thus, concretes from broken slag, which are those that show the highest tensile and compression strength, are definitely inferior as regards resistance to wear.

General organisation of the work.

The production is controlled in all its details by rational methods including the following factors :

a) Timing the work;

b) Monthly work programmes;

c) Distribution of the work;

d) Checking the progress of the work;

e) Inspection of the work as regards quality.

Timing. — As has been pointed out already the yards were laid out so that the work could be done in the shortest possible time.

Repeated timings under the supervision of experienced men were made and have enabled a table of production times to be drawn up for each part.

The following are some of the prescribed times :

40 open fence sections per gang of 6 men per 8 hours (each section weighs 115 kgr. = 253 lb.);

55 posts for lightened-out fence per gang of two men per 8 hours (each post weighs 90 kgr. = 198 lb.);

32 ordinary platform edges per gang of 2 men per 8 hours (weight per edge 130 kgr. = 287 lb.);

28 platform edges for raised platforms per gang of 2 men per 8 hours (weight per edge piece 133 kgr. = 300 lb.);

26 ditch trough sections per gang of 2 men per 8 hours (weight per section 221 kgr. = 487 lb.);

1 440 cable protection covers with 0.05 m. (2 in.) opening per gang of 5 men per 8 hours (weight per cover 10 kgr. = 22 lb.);

960 cable protection covers with 0.09 m. (3/8 in.) opening per gang of 5 men per 8 hours (weight per cover 17 kgr. = 37 1/2 lb.).

Mass production methods have to be used to get such figures, which are maximum outputs. In other words the same gang should do the same work so long as the programme allows. It has been found in practice that when a gang of expert concrete workers changes work several days practice is required before they can give the prescribed output. The relative loss of output is still greater with inexperienced men.

Preparation of the monthly programmes. — Every month the yard receives from headquarters a list of the parts to be supplied in the third following month. This list is compiled from the demand received from each out-of-doors service based on the work it has to do in accordance with the planning programme.

On receipt of this information the yard draws up a manufacturing programme of reinforced concrete parts and of the reinforcements themselves, the stock in hand, and the time for hardening being taken into account.

The programme also covers any new moulds needed. It also makes provision for manufacturing to stock so as to hold a stock equivalent to the average consumption during one month, and to be able to meet unexpected demands. The daily work tickets are prepared from the monthly programme.

Distribution of the work. — The programme is divided up between the various yards according to their capacity, layout, the specialisation of the gangs, and the quantity and nature of the parts to be made.

The work tickets for the different gangs are prepared by a staff thoroughly conversant with all these factors. Each ticket shows :

a) The nature of the work to be done;

b) The time allowed for it;

c) The gang responsible and the tool equipment involved;

d) The job preceding the new job to be done;

e) The dates the work is to be begun and completed.

These tickets are sorted by gangs according to the order in which the work is to be finished; the date the work is to be completed is only shown when the date the work in hand will be finished is known.

The work tickets are issued at the start of work each day to the gangs concerned; tickets are never issued for more than one day's work.

These work tickets are issued to the manufacturing gangs as well as to those doing the iron work and the labouring gangs. The labouring gangs generally form the reserve from which men are taken to replace absentees in the other gangs.

Only the joiners and fitters responsible for making and keeping the moulds and

tool equipment in order cannot work to prescribed times and to the planning system as their work includes to many unexpected jobs.

Checking the progress of the work. — When distributing the work tickets to the yards, a shop clerk prepares, on a roll of squared paper, a diagram showing the expected rate of progress. As the work is being done the first diagrams are completed by adding to them the actual rate at which the work progresses. The work tickets are returned to the works office at the end of the day and give all the information required as to the work done : they are also used for accountancy purposes.

The yard manager, with this information before him, easily finds out any irregularities in production, and can act quickly and effectively. He can also see to which gangs urgent or unexpected work can be given without upsetting the delivery dates of the rest of the production.

Checking the quality of the work. — If the output were pushed on without the quality of the work being rigorously checked at the same time, the result would be certain failure. Indeed, the work is hard and delicate so that the men, in order to attain the required output, might be tempted to overlook the question of quality.

Any irregularity in mixing the concrete, any defect in the forms, or any carelessness during handling produce defective parts even with the vibration process.

The main duty of the foremen is to watch the way the work is done and make good any defects.

Every defective or damaged part is either made good or scrapped.

The works manager, assisted by an inspector, particularly supervises the quality of the product and takes all necessary steps to prevent bad workmanship.

Finally the leading hand of the loading gangs is responsible for checking and stamping each part before sending it away. If the scrap becomes excessive the men to blame are suitably dealt with.

Preparation of cost prices.

The cost of the manufactured parts is obtained by a method based on the principle of constant stock taking.

In calculating the value of each part the first step is to cost the raw materials which by adding the wages and general charges, are transformed into semi-manufactured or fully manufactured products.

From the work tickets, the wages per part at each stage of manufacture can be determined. These stages, in chronological order, are :

1. Preparing the steel work;
2. Finishing the reinforcement by welding;
3. Preparing the concrete;
4. Moulding the parts.

The general charges, including some materials and wages, represent 25 % of the total expenditure.

The value of the materials used and charged to general charges is 16 % of the total value of the actual materials. The wages charged to general charges, i.e. those which cannot be booked directly against each part, amount to 40 % of the total wages cost which is itself 40 % of the total expenditure in the yard.

The principal items in the general charges are the following :

Loading and off-loading. — This takes

Fig. 21. — Loading by means of roller conveyors.

Fig. 22. — Handling heavy parts by means of a gantry crane with electric pulley block.

5 hours per cubic metre (3 h. 48 min. per cu. yard) of concrete, i.e. 22 % of the total wages or 9 % of the total expenditure. This percentage is very high and steps are being taken to reduce it. The work has been mechanised to some extent by using a gantry crane with electric hoist and by roller conveyors (figs. 21 and 22).

Steps are being taken to mechanise the work still further, and improve the supervision of the gangs and it is hoped the cost will be reduced.

Making and repairing forms and equipment. — This item has increased through the development of the vibration process; it will be reduced in the future by using metal moulds. It absorbs 7 % of the total expenditure.

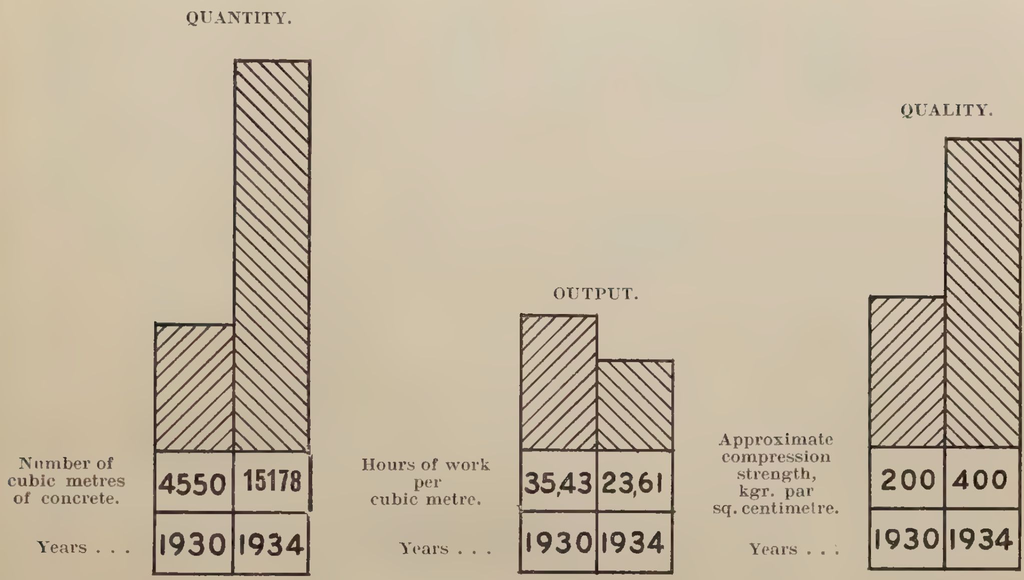
Construction and maintenance of the yard. — This item includes the construction and maintenance of the temporary buildings and tracks; it absorbs 5 % of the total expenditure.

The completed parts are finally entered in the stock book at their exact cost price.

The stock cards show the quantities manufactured fortnightly and their unit price. They are used when preparing the invoices when parts are issued.

Stocks.

By closely following up the orders and a methodical organisation of manu-



facture and issue, the stock is kept down to a minimum. The amount equals two months' production. The advantage is not only that less capital is locked up, but the area for stockage can be reduced.

Conclusion.

We think we have shown the extremely wide extent to which concrete can be used on railways and also the progress that can be made in a few years in a concreting yard. Investigation into the proportions of the mixtures and the use of vibration methods has increased the strength of the concrete; the use of metal moulds has improved the finish, and the organisation and mechanisation of the work has reduced the cost.

The above graphs show the results obtained from these efforts in the Roulers yard.

usually considered as bad, is relatively good. The poorest concrete as regards strength is that made with porphyry dust. The tests with this material showed how difficult it was to proportion the water. It contains a large proportion of impalpable dust which requires a larger volume of water. Further tests will be made with larger quantities of mixing water.

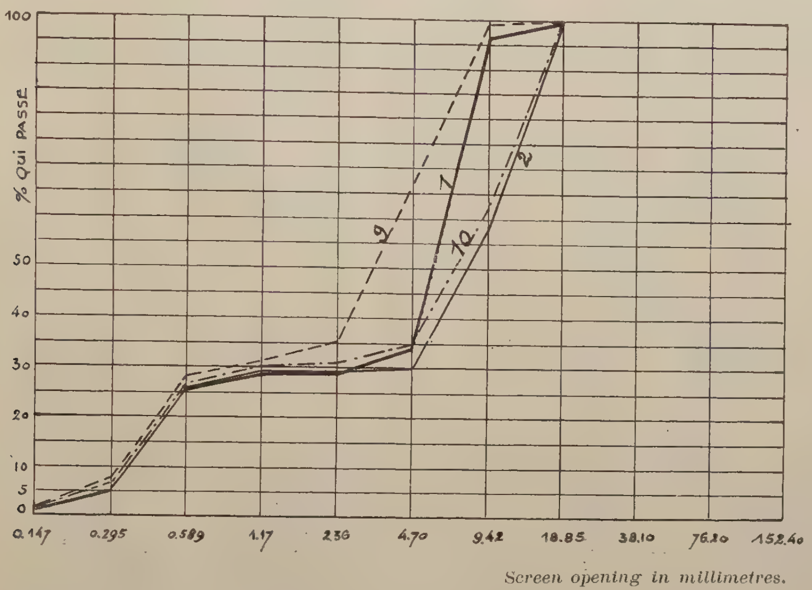


Fig. 19. — Granulometric diagram of the concretes of Table II.

Proportions of inert materials (Table IV).

When the concrete is vibrated the proportion of stone can be made very high, up to 3 volumes of stone for 1 of sand. Contrary to certain theories such concrete is hardly any stronger than less « stiff » concrete, i.e. with lower percentages of stone.

The granulometric diagrams (fig. 20) moreover are very irregular. The increased « stiffness » makes it more difficult to vibrate it and as the lower proportion of sand reduces to the extreme the quantity of mortar in which the stone is embedded, the concrete may be less compact and uniform and therefore more liable to defects.

The best vibrated concretes seem to correspond to 1 part of sand to 2 — 2.5 parts of stone (by volume).

Proportions of water (Table V).

In the case of vibrated concrete the fluidity cannot be measured at the vibrating table as the concrete separates out instead of spreading out. The Abrams cone shows no slump. Until some measure of fluidity can be defined the yard

TABLE .

Number of concrete.	P. A. D. R. cement.	Concrete mixtures. — Proportions per cubic yard. Sand. Origin.	Sand. Modulus of fineness.	Sand. Volume.	Coarse aggregate (stone). Origin and dimensions.	Coarse aggregate (stone). Volume.	Water. Volume.	C/W	After 28 days. Specific weight of concrete.	After 28 days. Compression strength.	After 28 days. Tensile strength.	After 28 days. Compactness.
	Lb.			*Cu. feet.*		*Cu, feet.*	*Br. gall.*	*(weight).*	*Lb./cu.yard*	*Lb./sq.inch.*	*Lb./sq.inch.*	
1	606	Rhine sand.	2.26	10.72	Porphyry 3/16"-3/8"	27.81	27.9	2.17	3 970	5 718	788	0.646
2	604	Mt.-St.-Guibert.	1.84	10.67	Do.	27.68	28.1	2.15	3 958	5 902	792	0.639
3	597	Sea sand.	1.50	10.56	Do.	27.41	28.4	2.10	3 921	5 362	779	0.634
4	606	Moll sand.	1.96	10.69	Do.	27.76	28.1	2.16	3 970	6 002	956	0.644
5	600	Porphyry dust.	2.75	10.64	Do.	27.57	30.1	2.00	3 882	4 793	767	0.634

TABLE IV.

Number of concrete.	P. A. D. R. cement.	Concrete mixtures. — Proportions per cubic yard. Sand. Origin.	Sand. Modulus of fineness.	Sand. Volume.	Coarse aggregate (stone). Origin and dimensions	Coarse aggregate (stone). Volume.	Volume. Water.	C/W	After 28 days. Specific weight of concrete.	After 28 days. Compression strength.	After 28 days. Tensile strength.	After 28 days. Compactness.
	Lb.			*Cu. feet.*		*Cu. feet.*	*Br. gall.*	*(weight).*	*Lb./cu.yard*	*Lb./sq.inch.*	*Lb./sq.inch.*	
1	594	Mt.-St.-Guibert.	1.84	9.07	Porphyry 3/16"-3/8"	29.24	26.7	2.22	3 919	6 216	814	0.592
2	600	Do.	Do.	10.15	Do.	28.54	27.3	2.20	3 939	5 902	852	0.619
3	607	Do.	Do.	12.34	Do.	26.84	28.9	2.10	3 988	6 500	781	0.660
4	604	Do.	Do.	13.28	Do.	25.68	29.4	2.05	3 988	5 504	653	0.669

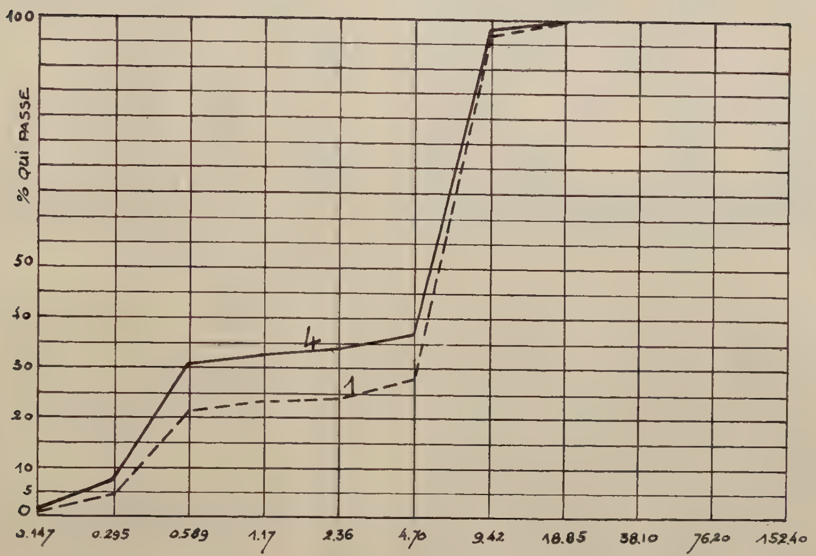


Fig. 20. — Granulometric diagram of the concretes of Table IV.

tests the concrete by squeezing up a handful and examining its plasticity.

Concretes of the same composition as regards dry materials have been tested with minimum average and maximum quantities of mixing water compatible with good manufacture (concretes 1 to 5).

The minimum quantities of water with which the concrete was workable gave the best results. Concrete is taken as workable when, after being vibrated 3 to 5 minutes, the mass becomes homogeneous and the cement appears at the top of the mould. If it does not, the concrete is too dry and gains little strength.

The best average quantities of water were about 170 l. per m³ (28.6 Br. gall. per cu. yard) for vibrated concrete, 200 to 230 l. per m³ (33.6 to 38.7 Br. gall. per cu. yard) for rammed concrete, and 230 to 265 l. per m³ (38.7 to 44.6 Br. gall. per cu. yard) for plastic concrete.

This quantity of mixing water depends upon the nature and size of the stone and sand and the quantities thereof.

To get the same plasticity the quantity of water ought to be increased :

a) the rougher the stone (See Table II: rough slag and smooth gravel);

b) The greater the proportion of sand (see Table IV); and

c) The larger the proportion of impalpable material in the sand (see conclusions in connection with porphyry dust).

With the same proportions of inert materials, 15 litres of water per m³ (2.52 Br. gall. per cu. yard) are enough to alter the concrete from too dry to too moist. Whilst the concrete is being vibrated and whilst setting 25 litres of water per m³ (4.2 Br. gall. per cu. yard)

TABLE V.

Number of concrete.	Concrete mixtures. — Proportions per cubic yard.							$\frac{C}{W}$	After 28 days.			
	P. A. D. R. cement.	Sand.			Coarse aggregate (stone).		Water.		Specific weight of concrete.	Compression strength.	Tensile strength.	Compactness.
		Origin.	Modulus of fineness.	Volume.	Origin and dimensions.	Volume.	Volume.					
	Lb.			Cu.feet.		Cu.feet.	Br. gall.	(weight).	Lb./cu.yard	Lb./sq.inch.	Lb./sq.inch.	
1	611	Mt.-St.-Guibert.	1.84	10.80	Porphyry 3/16"-3/8"	28.03	27.1	2.25	4 002	6 215	...	0.656
2	611	Do.	Do.	10.77	Do.	28 00	28.4	2.147	3 991	5 861	...	0.646
3	612	Do.	Do.	10.83	Do.	28.11	28.4	2.15	4 017	5 832	...	0.659
4	611	Do.	Do.	10.80	Do.	28.05	29.6	2.05	4 000	5 576	...	0.654
5	609	Do.	Do.	10.77	Do.	27.92	29.6	2.06	4 005	5 576	...	0.651
6	732	Do.	Do.	10.75	Do.	26.46	29.4	2.48	3 995	7 040	850	0.642
7	716	Do.	Do.	10.53	Do.	25.92	33.5	2.14	3 973	6 187	627	0.617

TABLE VI.

Number of concrete.	Concrete mixtures. — Proportions per cubic yard.							$\frac{C}{W}$	After 28 days.			
	P. A. D. R. cement.	Sand.			Coarse aggregate (stone).		Water.		Specific weight of concrete.	Compression strength.	Tensile strength.	Compactness.
		Origin.	Modulus of fineness.	Volume.	Origin and dimensions.	Volume.	Volume.					
	Lb.			Cu.feet.		Cu.feet.	Br. gall.	(weight).	Lb./cu.yard	Lb./sq.inch.	Lb./sq.inch.	
1	415	Mt.-St.-Guibert.	1.84	12.15	Porphyry 3/16"-3/8"	29.92	27.3	1.52	4 035	3 911	653	0.654
2	496	Do.	Do.	11.74	Do.	29 00	27.8	1.78	3 991	5 007	755	0.647
3	606	Do.	Do.	11 31	Do.	27.81	36.0	2.14	3 990	5 931	755	0.645
4	656	Do.	Do.	11.12	Do.	27.38	29.8	2.20	3 993	6 258	865	0.648
5	732	Do.	Do.	10.75	Do.	26.46	29.4	2.48	3 961	7 040	850	0.642
6	802	Do.	Do.	10.31	Do.	25.41	29 8	2.69	3 946	7 752	576	0.630
7	717	Do.	Do.	10 53	Do.	25.92	33.5	2.14	3 939	6 187	6 272	0.617

Note on Train Speeds,

by Lionel WIENER,
Professor at the University of Brussels.

PART II *(Continued).* (1)

Train speeds and services in different countries.

X. — JUGOSLAVIA.

SUMMARY.

CHAPTER XXXIX.

CHAPTER XXXIX.

XXXIX-1. — **General.** — The Jugoslav system is made up of independent railways which had to be co-ordinated. A few only of the old traffic currents are still extant, whilst most of the others changed and new ones were added.

Moreover the port of Fiume, which formerly depended upon Budapest, is now connected with Italy, and the port of Susak has been enlarged and brought under the influence of Belgrade, upon which too the narrow-gauge Bosnian railway system also depends.

The 1935 Summer timetables were used in this chapter.

XXXIX-2. — **Present frontiers** frequently cut through main lines whose sections therefore now lie in different States. As, moreover, large towns or districts formerly depending upon other towns had to be connected with the capital, the position in some of the frontier provinces is unusual. Many such instances occur in Jugoslavia.

This applies to most lines of the former *Südbahn*, and to other international railways as well.

a) From East to West, the line from Vienna and Graz to Villach and Innichen (San Candido) (formerly *Südbahn*) runs into Jugoslavia at Spielfeld Strass and after passing through Pragersko and Llubljana leaves the country between Jesenice (221 km. = 137.3 miles from Maribor, and 239 km. = 148.5 miles from Strass) and Rosenbah.

The line from Vienna and Graz to Trieste runs through Jugoslavia for 236 km. (146.6 miles) between Spielfeld Strass and Rakek (fig. 240).

b) The position is the same in the case of the line from Budapest to Nagykanisza-Pragersko-Klagenfurt (formerly

(1) Cf. *Bulletin of the Railway Congress*, October and November 1933; January, May, June and July 1934; February, March, April, May, July and October 1935.

Fig. 240. — International frontier lines in the North West of Jugoslavia.

Südbahn) which enters Jugoslavia at Kotoriba and leaves it between Prevalje and Bleiburg 198 km. (123 miles) further on. The Eastern section, as far as Pragersko, is still served by express trains which run through to Trieste and the Riviera but the Western has locals only, those between the Austrian towns of Graz and Villach, covering 106 km. (65.9 miles) of the journey in Jugoslavia.

c) The pre-war expresses of the Zagreb-Fiume railway ran via San Pietro. The last 87 km. (54 miles) of the 283 km. (178.5 miles) between Rakek and Fiume, are now in Italy (1).

d) South to North, the Italian portion of the Trieste, Villach and Linz main line is separated from the Austrian one by a 96-km. (59.6 miles) section from Bistrica-Bohini to Jesenice (2) which lies in Jugoslavia.

At both ends, the Jugoslav frontier is crossed in double-track international tunnels, the Wochein (6 339 m. = 3.94 miles long) and the Karawanken (7 975 m. = 4.95 miles long), part of both of which lies in Jugoslavia (3).

e) In the case of the Hungro-Rumanian lines, the frontier position is similar. Thus 128 km. (79.5 miles) of the Budapest-Bucharest line, between Szeged and Jimbolia, cut across the north-eastern corner of Jugoslavia, keeping just west of the Rumanian frontier (fig. 241).

So as to avoid these extra frontiers, the « Orient Express » which formerly followed this route has been shifted further West, and transferred from the Budapest-Szeged to the Budapest-Arad line.

Frontier sections. — There are some twenty international lines, only 3 of which to the southern and eastern fron-

(1) The distance from Zagreb to the port of Susak, opposite Fiume, is 229 km. (142.3 miles) via Ogulin. By railway, the distance is 24 km. (15.5 miles) between Susak and Fiume, via Skrljevo Junction which is half way between the two places.

(2) Piedicole is 112 km. (69.6 miles) from Trieste, and B. Bohini is 8 km. (4.9 miles) further on. Rosenbah is 9 km. (5.6 miles) beyond Jesenice (Assling).

(3) Jugoslavia now shares in the series of great transalpine lines. Beyond its northern frontier, the Trieste-Linz line crosses the Tauern tunnel, 8 526 m. (5,31 miles) long, opened in 1909, between Spittal and Bischofshofen.

The Bosruck tunnel, through the Dolomitic Alps between Selzthal and Linz, is only single track and is 4 765 m. (2.96 miles) long. The highest point on the line, in the tunnel, at an altitude of 727 m. (2 385 feet) is 1 250 m. (4 100 feet) below the top of the mountain.

The last range of the eastern Alps, the Wechsel, is pierced by the single-track Great Hartburg tunnel, 2 477 m. (1.54 miles) long, on the last section of the Graz-Vienna railway.

TABLE 227.

LENGTH OF INTERNATIONAL FRONTIER SECTIONS.

FRONTIER STATIONS.	Km.	Miles.	Administration.	To
To Italy.				
Rakek-Postumia (Postoina)	11	6.8	Italian.	Trieste (Trst).
Bistrica Bohini-Piedicole (Bodbrdo) . .	8	5.0	Do.	Gorizia and Trieste.
Planina-Tarvisio (Trbiz)	...	...	...	Udine.
To Austria.				
Jesenice-Rosenbah	9	5.6	Austrian.	Villach (Beljak).
Prevalje (Holmec)-Bleiburg	5	3.1	Jugoslav.	Klagenfurt.
Dravograd-Meza-Lawamünd (Labod) .	5	3.1	Do.	...
St. Ilj-Spielfeld-Strass	4	2.5	Do.	Graz-Vienna S.
Gor. Radgona-Radkersburg	3	1.9	Do.	Spielfeld-Strass.
To Hungary.				
Kotoriba-Nagykanisza	10	6.2	Hungarian.	Budapest.
Koprivnica (stops, then) Gyékényes . .	15	9.3	Jugoslav.	Do.
Virovitica (Lukac)-Barcs	17	10.6	Do.	Budapest and Vienna S.
Beli Monastir-Magyarboly	17	10.6	Hungarian.	Pecs.
Horgös (stops, then)-Szeged Rokus . .	19	11.8	Jugoslav.	Szeged.
V. Kikinda-Szöreg	50	31.0	Do.	Szeged + 3.7 miles.
To Rumania.				
V. Kikinda-Jimbolia	20	12.4	Do.	Timisoara.
Jasa Tomic-Nincicevo	10	6.2	Do.	Terminus.
Do. -Kruceni	3	1.9	Rumanian.	Timisoara.
Bela Crkva (stop, then) Bazias . . .	14	8.7	Jugoslav.	Danube.
To Bulgaria.				
Caribrod-Dragoman	21	13.0	Bulgarian.	Sofia.
To Greece.				
Devdelija-Aldomeni	...	...	Greek.	Solum.
Kremenica-Florina	15	9.3	Do.	Solum (narrow gauge).

tiers, 4 towards Italy, 5 towards Austria, 6 towards Hungary, and 4 towards Rumania. This great number is due to the fact that new frontiers were set up in regions which had already been developed and provided with railways built with-

Fig. 241. — International frontier lines in the North East of Jugoslavia.

out any idea that any change of political influence would take place.

XXXIX-3. — **Gradients and mountain lines.** — Heavy gradients had to be tolerated owing to the mountainous nature of the greater part of the country and the economic considerations under which most of the railways were built. Thus the lines from Zagreb to Susak, Ogulin to Split, Ljubljana to Novo Mesto, and Bubnjarci to Karlovac have 1 in 40 gradients. Elsewhere, gradients do not exceed 1 in 45. Secondary standard-gauge lines are occasionally steeper; the Grobelno-Rogatec line, for instance, has 1 in 36 gradients, and the Ruma-Vrdnik line, 1 in 40.

The minimum radius of curves is 300 m. (15 chains) safe in a few exceptional cases when they are 200 m. (10 chains) only and sometimes even less (1).

The Jugoslav railways do not climb to any considerable height; in spite of this, their building often entailed heavy engineering works, and many tunnels *(see table 228)*.

The maximum altitude reached on the Fiume-Belgrade line is 836 m. (2 742 feet) in the Lianka tunnel [near the 50th km. (31st mile)], from which point it falls towards Ogulin [323 m. (1 060 feet) above sea level] at the 120th km. (76th mile) (2).

East of Nis, the main line crosses the divide at 532 m. (1 745 feet) above sea level, and so down to Prechevo. Beyond Pirot, it runs through the famous Dragoman pass and reaches, beyond Caribrod, an altitude of over 726 m. (2 382 feet); it then falls towards Sofia which is 559 m. (1 834 feet) above sea level.

The Veles-Bitolj standard-gauge line gives a direct connection with Greece, without leaving Jugoslav territory. Until

(1) The minimum radii on the chief lines are :

180 m. (9 chains) between Zelenikovo and Pcinja (Skoplje-Devdelija line);

187 and 200 m. (9.35 and 10 chains) on the Zidani Most triangle (Zidani Most-Maribor line);

249 m. (12.45 chains) between Preserje and Borovnica (Ljubljana and Rakek line);

220 m. (11 chains) between Dravograde and Prevalje (Maribor Prevalje line).

(2) Beyond this, it runs along the fifteen Plivtice lakes, which lie between 639 and 506 m. (2 096 and 1 660 feet) above sea level, their length of 7 km. (4.35 miles) as the crow flies corresponding to a median length of 9 km. (5.6 miles); their maximum width is 500 m. (0.31 mile).

TABLE 228.

CHARACTERISTICS OF THE MAIN JUGOSLAV TUNNELS.

(Standard-gauge lines).

LINE.	Between the stations of	Name of tunnel.	Length.		Altitude.		Gradients.		Radius of curve in tunnel.	
			Kilom.	Miles.	Metres.	Feet.	1 in	1 in	Metres.	Chains.
Jesenice - Piedicole - Gorizia	Bohinjska and Piedicole.	Bohinj (Wochein).	6.339 (1)	3.94 (1)	530	1 739	67	...	...	...
Jesenice-Villach	Jesenice and Rosenbach.	Karawanke.	7.975 (2)	4.95 (2)	637 (2)	2 090 (2)	51	...	...	...
Ogulin-Split	Vrhovine and Sinac.	Sinac (Sinatz).	2.274	1.41	715	2 346	55	55	...	...
Kragujevac-Kraljevo	Dragobraca and Knic.	Vuckovica.	2.063	1.29	268	879	85	100	...	...
Veles-Prilep	...	Babuna (3).	2.573	1.60	..	...	...	...	...	...
Jesenice-Bohinj	Dobrava and Bled.	Vintgar.	1.181	0.73	564	1 850	40	125	...	
Do.	Bohinjska Bela and Soteska.	Oberne.	1.295	0.80	494	1 621	100	100	400-700	.. 20-35
Karlovac-Ljubljana	Ursna Sela and Semic.	Semis.	1.975	1.23	349	1 145	166	200	300-250	15-12.5
Srpske-Moravice-Susak	Skrad and Susak.	Kupjac.	1.222	0.76	733	2 405	500-100	500-100	275-2983	13.75-149
Lapovo-Skoplje	Dobre strane and Polumir.	Bela Glava.	1.005	0.62	296	971	62	250	300	15
Do.	Usce and Jonasicka Banja.	Dzelep.	1.100	0.68	389	1 276	114	114	300	15
Nis-Prahovo	Cokonjar and Tabanovac.	Sokomovac.	1.182	0 73	102	335	167	167	250-300	12.5-15
Topcider-Pozarevac	Topcider and Beli Potok.	Beli Potok.	1.483	0.92	154	505	244-116	244-116	2000	100
Belgrade-Nis	Ripanj and Ralja.	Ripanj.	1.613	1.00	226	741	588	200	...	...
Nis-Prahovo	Gramada and Svrljig.	Kremada.	1.700	1.06	445	1 460	172	474	300	15
Zagreb-Susak	Skrljevo-Susak.	Bradjdica.	1.838	1.14	2.4 to 42.5	8 to 139	48	...	300-350	15-17.5

(1) International tunnel, 3 933 m. (2.44 miles) of which are in Jugoslavia.
(2) International tunnel worked by the Austrian Federal Railways. 3 605 m. (2.24 miles of it are in Jugoslavia. Its altitude is that of the highest point above the Adriatic.
(3) Tunnel under construction.

the completion of the 44 km. (27 miles) from Prilep to Bitolj (April 1931), 135 km. (84 miles) of the 0.60-m. (1 ft. 11 5/8 in.) gauge bend from Prilep to Gradsko, a station of the Salonica Railway, were used. The new line crosses the Babuna pass by a 2 573-m. (1.6 miles) tunnel.

The Pristina-Pec railway (70 km. = 43.5 miles) is to be extended down to the Adriatic, which it will reach in the Cetinje district.

XXXIX-4. — **Track- and loading gauges.** — In addition to its 8 057 km.

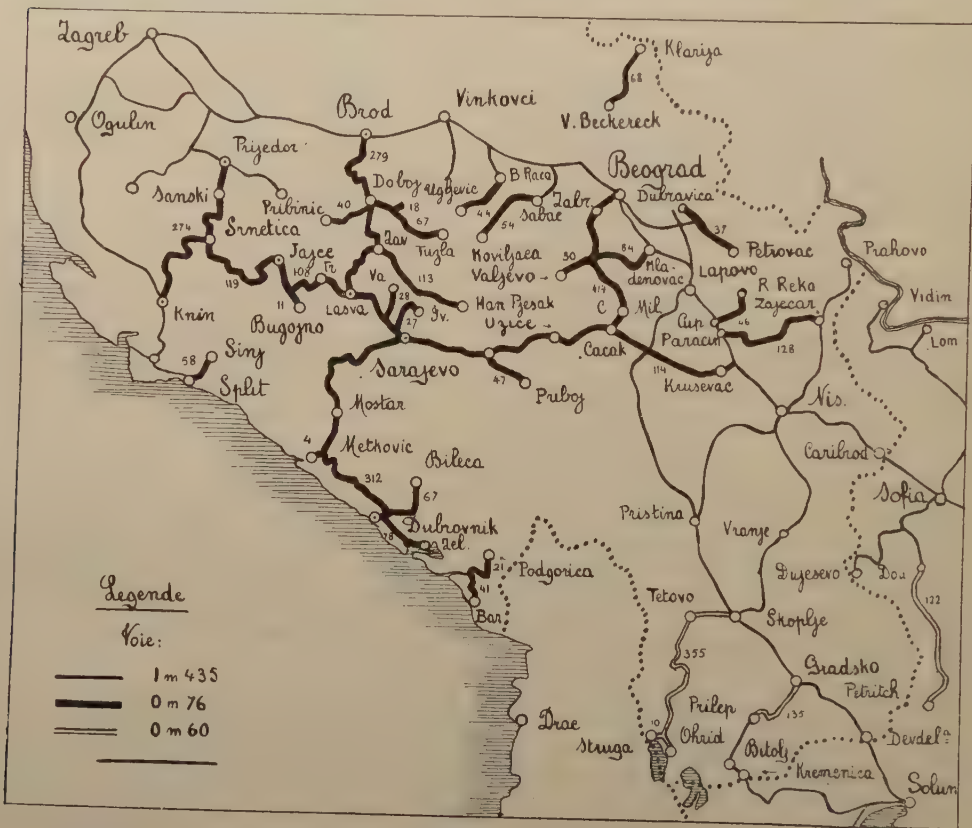


Fig. 242. — Jugoslav narrow-gauge railway system.

The figures show the length of the lines in kilometres.

(5 286 miles) of standard-gauge, Jugoslavia has an important system of 0.76-m. (2 ft. 5 7/8 in.) gauge lines, which grew out of the strategic Bosnia-Herzegovinian system and a number of 0.60-m. (1 ft. 11 5/8 in.) gauge lines including some 367 km. (228 miles) built by the Germans in southern Serbia and taken over after the War (fig. 242). The system is made up as follows :

GAUGE.	Operated by the Ministry of Communications.		Operated by the Ministry of Forests and Mines.		Total.	
	Km.	Miles.	Km.	Miles.	Km.	Miles.
4 ft. 8 1/2 in.	7 093	4 407.5	...	...	7 093	4 407.5
3 ft. 3 3/8 in.	...	...	183	113.7	183	113.7
2 ft. 5 7/8 in.	1 881	1 168.8	515	320.0	2 396	1 488.8
1 ft. 11 5/8 in.	379	235.5	177	110 0	556	345.5
Total . .	9 353	5 811.8	875	543.7	10 228	6 355.5

3 331 km. (2 069.8 miles) of railways, i.e. 41 % of the standard-gauge system, and 29 % of the whole system, are therefore built to other than the standard gauge (1).

The 76-cm. (2 ft. 5 7/8 in.) system centres on Sarajevo and runs through mountain districts under extremely difficult conditions, as will be gathered from the altitudes and distances given hereafter :

PLACE.	Distance.		Altitude.	
	Km.	Miles.	M.	Feet.
Metkovie . .	0	0	91	298
Konjica . .	122	75.8	280	919
Ivan . . .	141	87.6	876	2 874
Tarcin . .	149	92.6	645	2 116
Sarajevo . .				
Gravosa . .				
Uskoplje . .	21	13.0	350	1 148
Gabela . .	112	69.6		
Sarajevo . .				
Sarajevo . .				
Lasva . . .	64	39.8	359	1 178
Vranduk . .	93	57.8	584	1 916
Zepke Pass .	126	78.3		
Doboj . . .	185	115.0	146	479
Brod . . .	576	357.9		

Between Ivan and Tarcin, the mountain range which lies between Herzegovina and Bosnia reaches 1 012 m. (3 320 feet) above sea level. Between Uskoplje and Gabela is the valley of the Trebinjcica, which has no outlet.

Tunnels are also frequent on the narrow as on the standard-gauge lines; several of them are long.

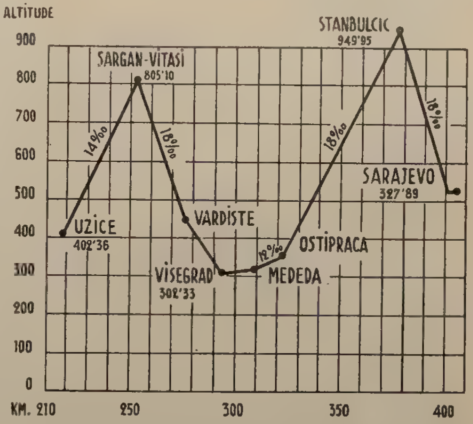


Fig. 243. — Gradient section of the Uzice-Sarajevo narrow-gauge line.

(1) The *State* operates 7 104 km. (4 414.3 miles) of standard-gauge lines, and private companies 953 km. (592.2 miles). The State also operates 1 881 km. (1 168.8 miles) of narrow-gauge lines, and private companies work 69 km. (42.9 miles).

TABLE 229.

FEATURES OF PRINCIPAL JUGOSLAV TUNNELS.
(2 ft. 5 7/8 in. gauge lines.)

LINE.	Nearest station on each side.	Tunnel.	Length.		Altitude.		Gradient.		Radius of curve, in tunnel.	
			Km.	Miles.	M.	Feet.	1 in	1 in	M.	Chains.
Sarajevo-Mostar	Rastelica and Bradina.	Jvan.	3.223	2.0	759.5	2 492	66	...	...	...
Paracin-Zajecar	Obradove-Stolice and Krivog Vira.	Cestobrodica.	1.921	1.19	554	1 818	500	66	...	...
Belgrade-Obrenovac	Umka and Mala Mostanica.	Umka.	1.614	1.0	120	394	500	200	300	15
Casak-Visegrad	Sardan-Vitasi and Jatara.	Alexander I.	1.667	1.04	807	2 647	400	100	150	7.5
Lasva-Bugojno	Goles and Gornji Oborci.	Komar.	1.362	0.84	777	2 549	100	500(1)	...	...

On the 185 km. (115 miles) of the Sarajevo-Uzice line there are 123 tunnels, with a total length of 20 123 m. (12.5 miles).

The gradients on the main 0.76-m. (2 ft. 5 7/8 in.) gauge lines reach 1 in 36 (2). Although the minimum radius of curves is usually 100 m. (5 chains), it exceptionally falls to 60 (3 chains) as at Ljubljanica on the Sarajevo-Brod line.

Riggenbach racks help to cross two summits of the 0.76-m. gauge lines : the first on the Sarajevo-Dubrovnik line, 759 m. (2 490 feet), and the second on the Lasva-Bugojno line, 779.5 m. (2 557 feet) above sea level (fig. 244). The chief characteristics are as follows :

TABLE 230.

RACK SECTIONS OF MIXED RACK-AND-ADHESION LINES OF THE JUGOSLAV RAILWAYS.

SECTIONS.	Length.		Maximum gradient	Smallest radius of curve.		Line.
	Km.	Miles.	1 in	M.	Chains.	
Bastelica-Konjie	12.091	7.52	20	125	6 1/4	Sarajevo-Mostar.
Oborci-Goles	6.261	3.89	22	150	7 1/2	Lasva-Bugojno.

(1) 1 in 33 on the 1′ 5 7/8″ lines.

(2) Paracin-Zajecar line. They are as much as 1 in 40 on the Sarajevo-Dubrovnik line and 1 in 55 on the Sarajevo-Uzice line.

TABLE 231.

TRAIN WEIGHTS AND SPEEDS ON STEEPEST GRADIENTS.

LOCOMOTIVE						Goods trains.				Passenger trains.			
Type.	Class.	Weight.		Maximum speed.		Weight.		Speed.		Weight.		Speed.	
		Metr. tons.	Engl. tons.	Km./h.	M. p. h.	Metr. tons.	Engl. tons.	Km./h.	M. p. h.	Metr. tons.	Engl. tons.	Km./h.	M. p. h.
0.76 m. (2 ft. 5 7/8 in.) gauge. *i = 1 in 40 to 1 in 36; R = 100 to 150 m. (5 to 7 1/2 chains).*													
2-8-2	85	82	80.7	50	49.9	...	...	...	...	85	83.7	22-25	13.7-15.5
0-8-2	83	52	51.2	35	21.7	100	98.4	15-18	9.3-11.2	90	88.6	22-25	13.7-15.5
0-10-2	88	50	49.2	30	18.6	140	137.8	15-18	9.3-11.2	...	...	...	...
2-6+6-0-T . . .	91	53	52.2	30	18.6	140	137.8	15-18	9.3-11.2	125	123.0	22-25	13.7-15.5
2-6+6-0	92	88	86.6	30	18.6	140	137.8	15-18	9.3-11.2	125	123.0	22-25	13.7-15.5
2-6+6-2	93	90	88.6	30	18.6	140	137.8	15-18	9.3-11.2	125	123.0	22-25	13.7-15.5
0-6-0 (2)	97	38	37.4	30 15 (rack)	18.6 9.3 (rack)	70	68.9	12-15	7.5- 9.3	70	68.9	12-15	7.5- 9.3
1.435 m. (4 ft. 8 1/2 in.) track. *i = 1 in 40; R = 300 m. (15 chains).*													
2-8-2	06	160	157.5	80	49.9	...	...	...	...	280	275.6	22-25	13.7-15.5
2-8-0	25/26	120	118.1	60	37.3	220	216.5	15-18	9.3-11.2	200	196.8	22-25	13.7-15.5
2-10-0	07/26	120	118.1	60	37.3	300	295.2	15-18	9.3-11.2	270	265.7	22-25	13.7-15.5
2-10-0	30	165	162.3	60	37.3	390	383.8	15-18	9.3-11.2	...	...	...	...
2-6+6-0	32	165	162.3	60	37.3	400	393.7	15-18	9.3-11.2	360	354.3	22-25	13.7-15.5

TABLE 232.

LEADING DIMENSIONS OF RECENT JUGOSLAV LOCOMOTIVES (1).

Type / Class		2-8-2 / 06	2-10-0 / 30	2-6-+6-0 / 32
Cylinders :	diameter	630 mm. (24 3/4 in.).	550 mm. (21 11/16 in.).	850 mm. (33 1/2 in.).
Boiler :	diameter	1.81 m. (5 ft. 11 9/32 in.).	1.81 m. (5 ft. 11 9/32 in.).	1.75 m. (5 ft. 9 in.).
	height of centre line	3.30 m. (10 ft. 10 in.).	3.30 m. (10 ft. 10 in.).	3.12 m. (10 ft. 3 in.).
	length	5.20 m. (17 ft. 1 in.).	5.20 m. (17 ft. 1 in.).	5.60 m. (18 ft. 4 1/2 in.).
Wheels :	diameter	0.90 m. (2 ft. 1/2 in.). 1.60 m. (5 ft. 3 in.). 1.10 m. (3 ft. 7 5/16 in.).	0.90 m. (2 ft. 11 1/2 in.). 1.35 m. (4 ft. 5 5/32 in.). ...	0.95 m. (3 ft. 1 3/8 in.). 1.44 m. (4 ft. 8 23/32 in.). ...
Wheelbase :	rigid	5.55 m. (18 ft. 9/16 in.).	6.90 m. (22 ft. 7 11/16 in.)	2×3.40 m. (2×11 ft. 2 in.).
	total	10.65 m. (34 ft. 11 5/16 in.).	9.85 m. (32 ft. 4 in.).	11.90 m. (39 ft. 1/2 in.).
Overall dimensions :	height	4.60 m. (15 ft. 1 in.).	4.60 m. (15 ft. 1 in.).	4.65 m. (15 ft. 3 in.).
	length	13.45 m. (44 ft. 1 9/16 in.).	13.45 m. (44 ft. 1 9/16 in.).	14.474 m. (47 ft. 6 in.).
	width	3.05 m. (10 ft.).	3.05 m. (10 ft.).	3.10 m. (10 ft. 2 in.).
Weight in working order		94.81 t. (93.3 Engl. tons).	107.18 t. (105.5 Engl. tons).	106.43 t. (104.7 Engl. tons).
Do. adhesive		64.44 t. (63.4 Engl. tons).	91.17 t. (89.7 Engl. tons).	94.69 t. (93.2 Engl. tons).
Maximum axle load		17.78 t. (17.5 Engl. tons).	18.07 t. (17.8 Engl. tons).	15.77 t. (15.5 Engl. tons).

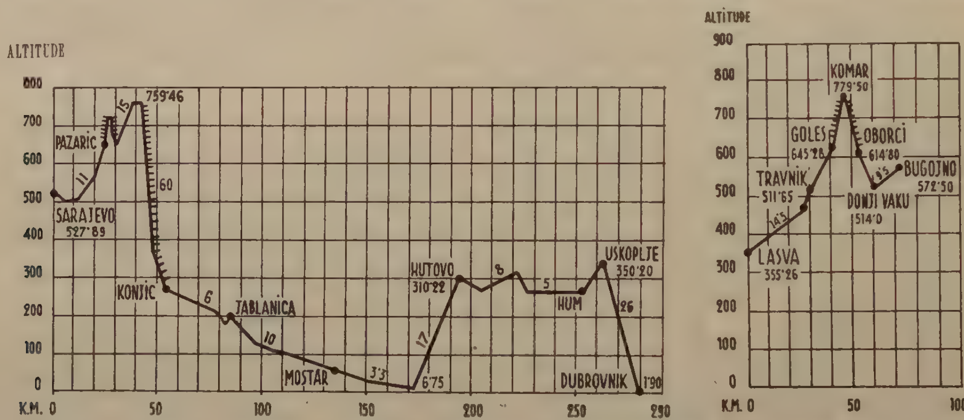


Fig. 244. — Gradient section of the Sarajevo-Dubrovnik and Lasva-Bugojno narrow-gauge lines.

The rack sections are shown by cross hatched lines.

(1) There are no recent rack locomotives. The leading dimensions of those still in service, all fitted with two gear wheels, are as follows :

Weight in working order	24 t. plus 13.4 t. (23.6 plus 13.2 Engl. tons for the tender).
Rigid wheelbase	2.325 m. (7 ft. 7 1/2 in.).
Tender wheelbase	1.200 m. (3 ft. 11 1/4 in.).
Length over buffers	10.128 m. (33 ft. 2 3/4 in.).
Maximum height	3.400 m. (11 ft. 2 in.).
Boiler centre, height	1.700 m. (5 ft. 7 in.).

Figure 245 shows the loading gauge of the 0.76-m. (2 ft. 5 7/8 in.) gauge lines.

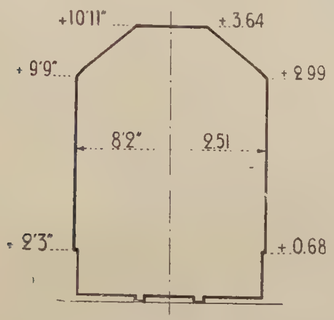


Fig. 245. — Loading gauge of the 0.76-m. (2 ft. 11 5/8 in.) lines.

It is relatively small in comparison with those used elsewhere.

Owing to the mountainous nature of the country, articulated locomotives of all the usual types have been used : Krauss, Hagans, and at the present time, Klien-Lindner and Mallet. They meet the requirements shown in table 231 to which, for purposes of comparison, we have added the conditions required from standard-gauge locomotives.

The most interesting average speeds on narrow-gauge lines (0.76 and 0.60-m.) are shown hereunder (table 233) :

TABLE 233.

NOTEWORTHY RUNS ON JUGOSLAV NARROW-GAUGE LINES.

RUN.	Distance.		Time of departure.	Time spent.	Speed.		Number of stops.	—
	Km.	Miles.			Km./h.	Miles/h.		
0.76-m. (2 ft. 11 5/8 in.) gauge lines.								
Belgrade-Sarajevo . . .	444	275.9	9.10 a. m.	13.34	32.7	20.3	22	
Belgrade-Umka . . .	23	14.3	Do.	0.41	33.6	20.9	—	
Umka-Lajkovac . .	40	24.9	10.22 a. m.	1.01	40.0	24.9	—	
Prijevor-Pozega . .	29	18.0	2.58 p. m.	0 46	37.8	23 5	—	
Pozega-Uzice . . .	27	16 8	3.45 p. m.	0.45	35.8	22.2	—	
Paracin-Jazecar . . .	128	79.5	3.15 a. m.	5.49	22.0	13.7	21	
Krusevac-Kraljevo-Cacak	114	70.8	5.02 a. m.	3.28	32.9	20.4	21	
Prilep-Kremenica . . .	62	38.5	5.00 a. m.	1.56	32.0	19.9	6	
Brod-Sarajevo	279	173.4	3.20 a. m.	8.50	31.6	19.6	17	
Bosna-Brod-Derventa .	24	14.9	3.30 a. m.	0.44	32.7	20.3	—	
Podlugovi-Rajlovac .	16	9.9	11.29 a. m.	0.27	35.6	22.1	—	
Sarajevo-Dubrovnik . .	312	193.9	11.40 p. m.	10.35	29.5	18.3	22	with rack section.
Uskoplje-Dubrovnik .	24	14.9	9.33 a. m.	0.42	34.3	21.3	—	
0.60-m. (1 ft. 11 5/8 in.) gauge lines.								
Gradsko-Prilep	135	83.9	3.40 a. m.	7.03	19.2	11.9	13	
Skoplje-Ohrid	355	229.6	5.50 a. m.	15.26	32.5	20.2	43	

RAILCARS. — At the present time, there are no fast railcar services. Two units, now in service, do not exceed the speed of 50 km. (31 miles) an hour, but six new ones now on order, will be faster.

XXXIX-5. — Jugoslav train speeds. — Noteworthy runs are shown in tables 235 and 236, and the maximum commercial speeds on the various lines of the system run over by express trains are shown in figure 246.

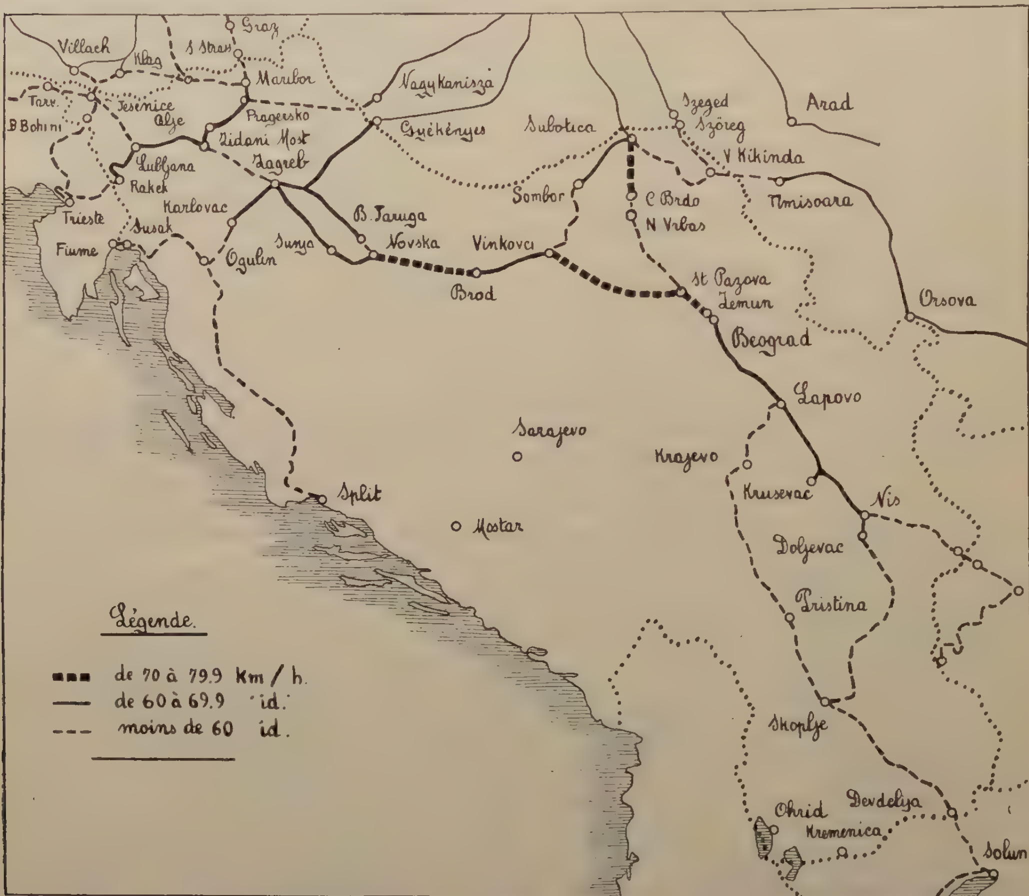


Fig. 246. — Cartogram of maximum overall train speeds on the Jugoslav Railways.

Legend :

▬ ▬ ▬ 43.4 to 49.9 m. p. h.
——— 37.4 to 43.4 m. p. h.
- - - - Below 37.4 m. p. h.

Taking the standard gauge system as a whole :

312 km. (193.9 miles) or 3.3 % are run over by trains averaging 70 to 79.9 km. (43.4 to 49.9 miles) an hour;
1 050 km. (652.5 miles) or 13.1 % at 60 to 69.9 km. (37.4 to 43.4 miles) an hour; and
6 695 km. (4 160 miles) or 83.6 % at less than 60 km. (37.4 miles) an hour.

No train reaches 80 km. (49.9 miles) an hour.

Fuel used. — In Central and Eastern Europe the question of fuel is of greater importance than in the West, as the coal at hand, often of poor quality, must be made the best of.

Express and mountain locomotives burn, in the proportion of 1 : 2, a mixture of either coal or briquettes with good quality brown coal. Table 234 gives a few particulars of the different kinds of fuel used.

TABLE 234.

CHARACTERISTICS OF THE FUEL BURNT IN JUGOSLAV LOCOMOTIVES.

FUEL.	Calorific value. B.T.U./lb.	Evaporating power.	Percentage of ash.	Percentage of humidity.
Lignite . .	6 300- 7 200	3 to 3.5	10 to 12	30 to 50
Lignite . .	7 200- 9 000	3.5 to 4.5	12 to 18	15 to 30
Coal . . .	9 000-11 700	4.5 to 5.5	18 to 25	5 to 15
Briquettes .	11 700	5.5	25	3 to 5

XXXIX-6. — **The International Sleeping-Car Company's services** (fig. 247). — The cession of Croatia to Jugoslavia brought within Jugoslav territory some of the former *Südbahn* Co.'s lines including those followed by the Vienna and Budapest portions of the « Vienna-Tyrol-Riviera Express » (1).

Only the great trains from the East still use it.

Beyond Budapest, the « Orient Express » split into two sections, a Rumanian and a Turkish one. As has been explained, the former, which ran through Szeged, V. Kikinda, and Jimbolia has been diverted more to the East so as to run directly from Hungary into Rumania via Arad.

The other portion of the « Orient Express » still runs from Subotica to Belgrade and Nis, where it is again split up; one section continues to Sofia and Istanbul, and the other to Athens.

The post-war « Simplon Orient Express » crosses the country from West to East and makes a detour to the North from Vinkovci to Subotica before returning to Jimbolia where it joins the old route of the « Orient Express » via Timisoara, Turnu Severin and Bucharest.

A direct line from Belgrade to Orsova via Bela Crkva would give a through connection from the capital to Bucharest and reduce by half (263 km. = 163.4 miles instead of 488 km. = 303.2 miles) the run of the « Simplon Orient » besides having the additional advantage of serving Belgrade.

The 61 km. (37.9 miles) of the Belgrade-Kucevo railway are under construction. This line is intended to reach the Danube at Orsova, but the exact location of the new Danube bridge has not yet been decided. Its length, depending upon the site selected, will be from 800 to 900 m. (2 625 to 2 950 feet) or even 1 200 m. (3 600 feet).

The double-track bridge on the 26-km.

(1) Discontinued in 1913.

TABLE 235.

JUGOSLAV TRAIN SPEEDS.

(Non-stop runs are shown in **heavy** type).

RUN.	Distance.		Time of departure.	Time spent.	Speed.		Number of stops.	—
	Km.	Miles.			Km. h.	Miles/h.		
Belgrade-Zagreb-Rakek	620	385.3	9.55 p. m.	10.53	60.9	37.8	7	Simplon Express.
Belgrade-Vinkovci-Zagreb . . .	436	270.9	9.55 p. m.	8.00	54.5	33.9	4	Do.
Belgrade-Ruma	**74**	**46.0**	**Do.**	**0.58**	**76.5**	**47 5**	...	Do.
Ruma-Vinkovci	**91**	**56.7**	**10.54 p. m.**	**1.18**	**70.0**	**43.5**	...	Do.
(Belgrade) Zagreb-Rakek (Trieste)	194	120.5	5.05 a. m.	3.44	57.0	35.4	2	Do.
Zidani Most.-Ljubljana . . .	**64**	**39.8**	**R 9.45 p. m.**	**1.03**	**60.9**	**37.8**	...	Do.
Zagreb-Maribor (Vienna) . . .	170	105.6	12.15 p. m.	3.55	47.4	29.4	10	
Celje-Pragersko	**49**	**30.4**	**R 3.27 a. m.**	**0.46**	**64.0**	**39.8**	...	
(Vienna S.) Maribor - Ljubljana - Rakek (Trieste)	207	128.6	R 11.40 p. m.	3.45	55.2	34.3	3	
Maribor-Pragersko	**18**	**11.2**	**2.00 p. m.**	**0.17**	**63.5**	**39.4**	...	
(Belgrade) Llubljana - Jesenice (Trieste)	65	40.4	10.00 a m.	1.26	45.4	28.2	3	
(Vienna S.) Maribor - Kotoriba (Budapest)	110	68.3	2 58 a. m.	2 00	55.0	34.2	5	
(Vienna S. et Belgrade)-Zagreb-Susak	229	142.3	2.20 a. m.	5.22	42.7	26 5	10	
(Vienna S. et Belgrade)-Zagreb-Fiume	229	142 3	Do.	5.29	41.3	25.7	10	
(Vienna S. et Belgrade)-Zagreb-Split	424	263.4	11 00 p. m.	10.03	42.4	26.3	11	
Zagreb-Karlovac	**53**	**32.9**	**Do.**	**0.51**	**62.3**	**38.7**	...	
(Susak) Zagreb-Kaprivnica (Budapest)	89	55.3	R 12.43 a. m.	1.27	51.1	31.8	3	
(Belgrade) Vinkovci-Subotica .	132	82.0	5.06 a. m.	2.29	53.2	33.1	5	Simplon Express. to Bucharest.
Sombor-Bajmok	**32**	**19.9**	**R 10.10 p. m.**	**0 31**	**61.9**	**38.5**	...	Do.
Belgrade-Subotica	185	115.0	R 4.00 a. m.	3.15	56.0	34.8	7	Orient Express.
Zemun Stara-Pazova	**29**	**18.0**	**R 6.38 a. m.**	**0.28**	**62.2**	**38.7**	...	Do.
Novi Sad-Novi Vrbas	**42**	**26.1**	**11.48 p. m.**	**0 37**	**68 1**	**42.3**	...	Do.
Novi Vrbas-Subotica	**60**	**37.3**	**R 4.00 a. m.**	**0.52**	**69.2**	**43.0**	...	Do.
Belgrade-Devdelija	630	391.9	7.50 a. m.	12.03	52.3	32.5	16	Do. Athens section.
Belgrade-Lapovo	**114**	**70 8**	**Do.**	**1.40**	**68.4**	**42.5**	...	Do.
Lapovo-Cuprija	**39**	**24 2**	**9.31 a. m.**	**0.34**	**70.0**	**43.5**	...	Do.
Cuprija-Nis	**95**	**59.0**	**10.13 a. m.**	**1.24**	**67.8**	**42.1**	...	Do.
Nis-Leskovac	**45**	**28.0**	**12.10 p. m.**	**0.43**	**62.8**	**39.0**	...	Do.
Belgrade-Nis-Caribrod	347	215 6	7.50 a. m.	5.55	58.7	36.5	5	Do. Istanbul section.
Nis-Pirot	**73**	**45.4**	**11.51 a. m.**	**1.22**	**52.2**	**32.4**	...	Do.

TABLE 236.

NOTEWORTHY JUGOSLAV TRAIN RUNS.

RUN.	Distance Km.	Distance Miles.	Time of departure.	Time spent.	Speed Km./h.	Speed Miles/h.	
Fastest runs.							
Belgrade-Ruma (Zagreb) . . .	74	46.0	9.55 p. m.	0.58	76.5	47.5	Simplon Express.
(Belgrade) Brod-Novska	87	54 1	R2.34 a. m.	1.14	70.6	43.9	Do.
(Belgrade) Ruma-Vinkovci . .	91	56.5	10.54 p. m.	1.18	70.0	43.5	Do.
(Belgrade) Lapovo-Cuprija (Nis).	39	24.2	9.31 a. m.	0.34	70.0	43.5	Athens Express.
Longest non-stop runs.							
(Belgrade) Novska-Caprag-Zagreb	118	73.3	3.05 a. m.	1.50	64.4	40.0	Simplon Express.
Belgrade-Lapovo (Nis)	114	70.8	7.50 a. m.	1.40	68.4	42.5	Athens Express.
(Belgrade) Cuprija-Nis	95	59.0	10.13 a. m.	1.24	67.8	42.1	Do.
(Belgrade) Ruma-Vinkovci . .	91	56.5	10.54 p. m.	1.18	70.0	43.5	Simplon Express.
(Belgrade) Brod-Novska (Zagreb)	87	54.1	R2.34 a. m.	1.14	70.6	43.9	Do.

Fig. 247. — *International Sleeping Car Company* train services in Jugoslavia.

Legend : Sleeping-Car Co. trains.
Do. (discontinued).
Do. (outside Jugoslavia).

TABLE 237.

TRAINS OPERATED BY THE INTERNATIONAL SLEEPING-CAR COMPANY, SERVING JUGOSLAVIA (1935 Summer).

(Obsolete services are shown *in italics*).

Route: Origin.	Route: Jugoslav section.		Route: Destination.	Distance: Km.	Distance: Miles.	Time of departure.	Time spent.	Name of train.
	West to East.							
Vienna S.	*Maribor*	*Bleiburg-Klagenfurt*	*Cannes.*	128	79.5	*3.19* a. m.	*3.36*	*Vienna-Tyrol-Riviera.*
Budapest.	*Nagykanisza*	*Bleiburg-Klagenfurt*	*Cannes.*	257	*159.7*	*12.21* a. m.	*6.34*	*Vienna-Tyrol-Riviera.*
	North to South transit.							
Paris E. and Ostend.	Subotica-Belgrade	Caribrod	Istanbul.	532	330.6	4.00 a. m.	9.49	Ostend-Vienna Express.
Paris E. and Ostend.	Subotica-Belgrade	Devdelija	Athens.	815	506.4	4.00 a. m.	15.49	Orient Express.
Calais and Paris P.L.M.	Rakek-Vinkovci	Belgrade-Devdelija	Do.-Piræus.	1 295	804.7	8.24 p. m.	23.05	Simplon Orient. Express.
Calais and Paris P.L.M.	Rakek-Vinkovci	Belgrade-Caribrod	Istanbul.	976	606.5	Do.	17.03	Do.
Calais and Paris P.L.M.	Rakek-Vinkovci	Velika-Kikinda .	Bucharest.	705	438.1	Do.	13.20	Do.

(16.2 miles) long Belgrade-Pancevo line crosses the Danube near Belgrade and is 1 391 m. (4 564 feet) long. It was opened towards the end of the year, and until such time as a second railway track may be laid, road traffic is allowed over it.

XI. — BULGARIA AND TURKEY IN EUROPE.

SUMMARY.

CHAPTER XL.

1. General.
2. The Bulgarian railway system.
3. Railways of Turkey in Europe.
4. The International Sleeping-Car Company's trains.

CHAPTER XL.

XL-1. — **General.** — There is very little to be said about Bulgaria, whose mountainous railway system is still incomplete. This is due to the fact that the great Balkan range runs across the country from end to end and is doubled in the South, by the Rhodope range.

The international line from Belgrade to Sofia and Istanbul enters Bulgaria by the Dragoman Pass where it reaches its maximum height of 726 m. (2 382 feet) above sea level; it then descends through Sofia (537 m. = 1 762 feet) to the Maritza Valley, 64 m. (210 feet) at the frontier station of Svilengrad [1].

Although most of the railways pick their way between the mountains, one of them, the trans-Balkanic line, crosses the range from North to South, between Gorna-Orehovitza and Stara-Zagora, a distance of 152 km. [2] (94.4 miles). The gradient steepens from Tirnovo (160 m. = 525 feet) and Trevna (447 m. = 1 467 feet above sea level, 41st km. = 25.5th mile from Tirnovo) with a 1 in 40 ruling gradient for 16 km. (10 miles) from Platchkovtzi (526 m. = 1 725 feet above sea level, 48th km. = 30th mile) up to the summit

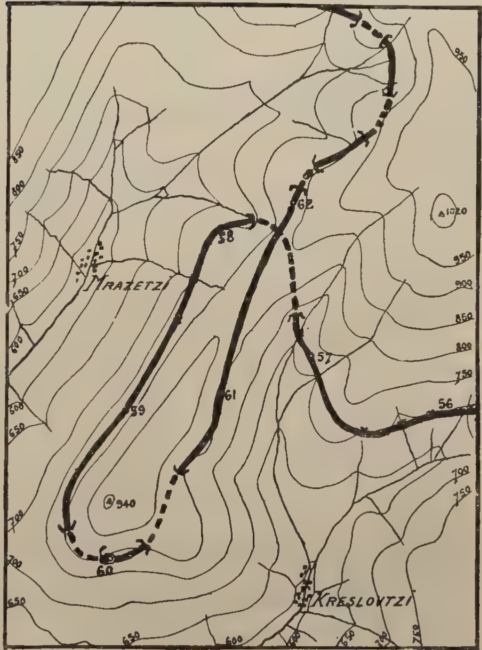


Fig. 248. — Tirnovo-Borouchtitza-Stara Zagora line.
The loop at Basovetz.

which is reached at Krestetz (882 m. = 2 894 miles above sea level, 64th km. = 40th mile from Tirnovo). To achieve this, there is a series of spirals and helical tunnels, which it is somewhat sur-

[1] Tzaribrod on the opposite frontier is 445 m. (1 460 feet) above sea level.

[2] 171 virtual km.

prising to find in this part of Europe on a line which does not appear to be of primary importance.

The first of these artificial layouts occurs near Krestetz (fig. 248) [1] between Platchkovtzi and the 62nd km. (38.5th mile) (822 m. = 2 697 feet above sea level). The second (fig. 249) [1] is

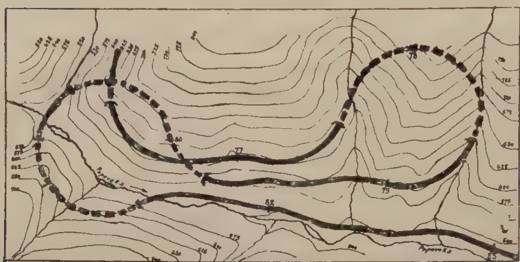


Fig. 249. — Loops and spiral tunnels near Radountzite.

on the opposite slope in the Borouchtitza district (72nd km. = 44.7 miles), (735 m. = 2 411 feet) altitude [2]. The entire line is quite remarkable, and deserves to be better known than it is.

The Bulgarian system consists of :

2 796 km. (1 489.2 miles) standard gauge line;
162 km. (100.7 miles) 0.76-m. (2 ft. 5 7/8 in.) gauge line;
257 km. (159.7 miles) 0.60-m. (1 ft. 11 5/8 in.) gauge line.

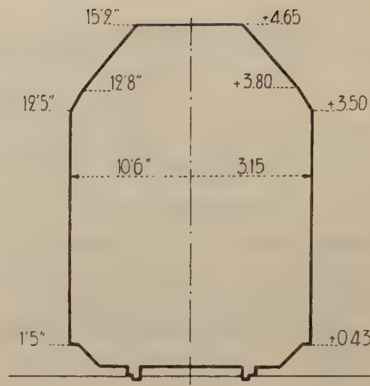


Fig. 250. — Loading gauge of the standard-gauge Balkan railways.

The loading gauge (fig. 250) is similar to Central European ones.

Frontier lines. — The main line has, we think, a unique feature, in the frontier region (fig. 255). Although for 73 km. (45.4 miles) it runs through a corner of Greece after leaving Bulgaria at Svilengrad and before entering Turkey near Pythion [3], it has already, on the way, passed through the latter country in order to serve Karaagatch (Edirne station at the 37th km. = 23rd mile), so that the railway actually crosses four frontiers

(1) To avoid boring lengthy spiral tunnels, it was found possible to lay out an elongated loop with three small tunnels only. This loop is 4 200 m. (2.6 miles) long and climbs 86 m. (282 feet). The 1 in 40 ruling gradient is reduced to 1 in 50 in the tunnels.

(2) This double spiral lies between the 76.2nd km. (47.3rd mile) at 617 m. (2 024 feet) above sea level, and the 81.7th km. (50.8th mile) at 513 m. (1 683 feet), the distance as the crow flies being only 625m. (0.39 mile) and the difference in altitude 104 m. (341 feet). The spirals have a radius of 275 m. (13 3/4 chains); the first is 1 349 m. (0.84 mile) long, 1 000 m. (0.62 mile) being underground, and the second 1 858 m. (1.15 mile) with only 760 m. (0.47 mile) of tunnel.

(3) The distance between Svilengrad and Pythion is 72 766 m. (45.20 miles); from the frontier to Pythion it is 1 296 m. (0.80 mile).

to reach the country which formerly used to join Bulgaria. The journey is now split up among three countries as follows :

		Km.	Miles.
Bulgaria.	Svilengrad to the Greco-Bulgarian frontier	3.895	2.42
Greece.	Greco-Bulgarian frontier to that of the Karaagatch enclave (Andrinople)	30.512	18.95
Turkey.	The Karaagatch enclave	7.136	4.44
Greece.	Frontier of the enclave to Pythion, and to the Greco-Turkish frontier (31.423 km. + 1.296 km.)	32.719	20.32
Turkey.	Frontier at Maritza (middle of bridge) to Istanbul	281.587	175.00
		355.149	221.13

XL-2. — **The Bulgarian railway system.** — All the important lines run from Sofia to the frontiers by roundabout routes which are gradually being improved. Nowhere does the overall speed reach 60 km. (37.4 miles) an hour (fig. 251).

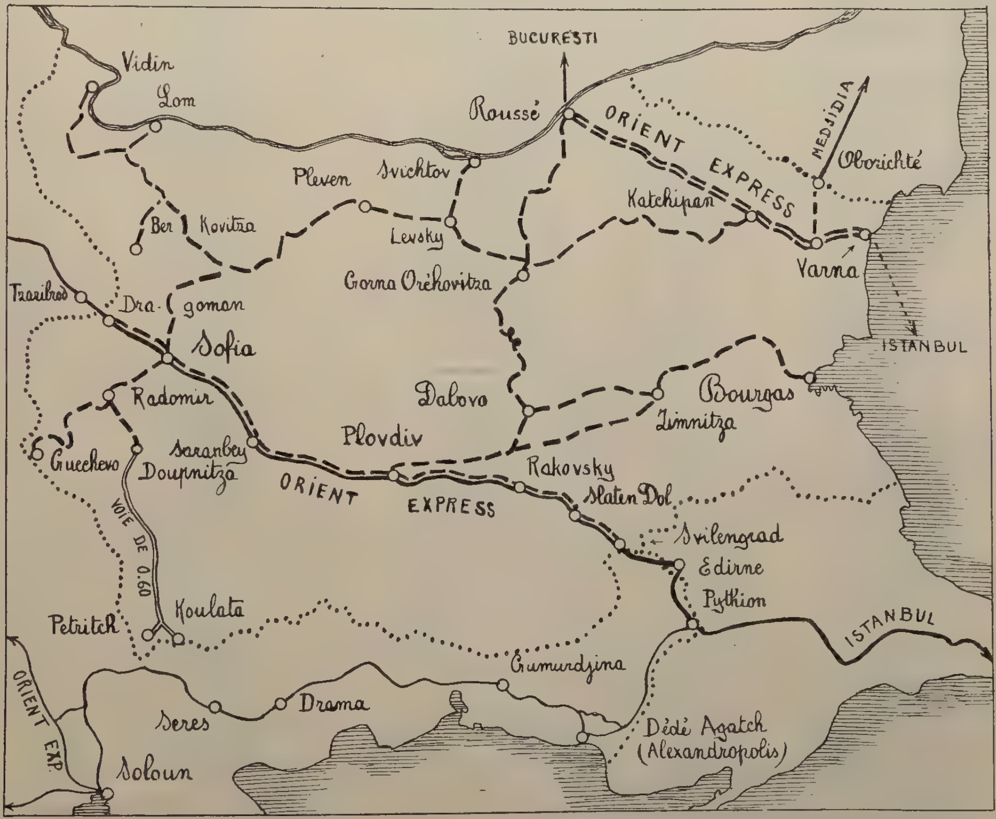


Fig. 251. — Cartogram of maximum overall speeds over the Bulgarian Railways. Also Bulgarian services of the International Sleeping-Car Co.

In Bulgaria, bar lines show runs made at less than 60 km. (37.4 miles) an hour. International Sleeping-Car Co. trains are shown by double lines, full when still in existence, broken when obsolete. 0.60-m. gauge lines are shown by thin double lines.

TABLE 238.
NOTEWORTHY RUNS ON THE BULGARIAN RAILWAYS.

RUN.	Virtual distance. Km.	Actual distance. Km.	Actual distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Number of stops.	—
Tzaribrod-Sofia-Svilengrad	395	362	224 9	3.02 p. m.	8 08	44.5	27.7	11	Orient Express.
Sarambey-Maritza	25	26	16.2	7.12 p. m.	0.28	55.7	34.6	...	Do.
Rakovsky-Svilengrad	74	65	40 4	9.57 p. m.	1.13	53.4	33.2	...	Do.
Plovdiv-Borisovgrad	46	45	28 0	8.22 p. m.	0.51	53.0	32 9	...	Do.
Sarambey-Plovdiv	52	53	32.9	R9.24 a. m.	1.02	48.4	30.1	...	Do.
Sofia-Varna	584	541	336.2	R7.30 p m.	11.55	45.4	282.1	24	
Guebedjé-Kaspitchan	66	63	39.1	5.55 p. m.	1.12	55.3	34.4	...	
Provadia-Varna	57	57	35.4	1.22 p. m.	1.06	47.3	29.4	...	
Sofia-Plovdiv-Bourgas	478	450	279.6	9.00 a. m.	10.30	42.9	26.7	29	
Roussé-Kaspitchan-Varna	275	225	139.8	9.00 a. m.	5.28	41.2	25.6	6	

The *Bulgarian Railways* own two series of twelve-coupled goods locomotives. They work on sections with 1 in 40 gradients and 275 m. (13 3/4 chains) and, exceptionally, 250 m. (12 1/2 chains) radius curves.

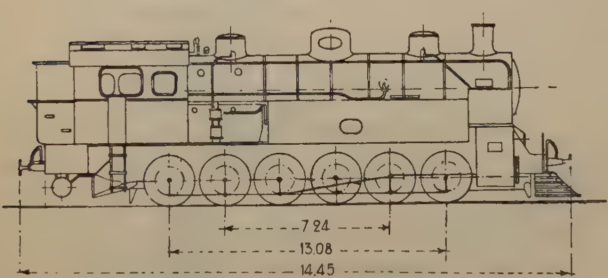


Fig. 252. — Bulgarian 0-12-0-T tank engine.

The 0-12-0-T two-cylinder compound locomotives (fig. 252) built in 1922 by the Hanover Locomotive Works, haul 300 tons at a speed of 15 to 20 km. (9.3 to 12.4 miles) an hour. They can attain a maximum speed of 45 km. (28 miles) an hour [1].

The 2-12-4-T locomotives (figs. 253*a* and 253*b*), built in 1931 by the Cegielski Works, of Poznan [2], haul trains of 420 tons at a speed of 20 km. (12.4 miles) an hour on the trans-Balkanic railway which climbs continuously for a distance of 16 km. (10 miles). Their maximum speed is 65 km. (40.4 miles) an hour.

These lignite-burning locomotives (Pernik lignite has a calorific value of 6 840 and 7 560 B.T.U./lb.) do good work and the Bulgarian railway authorities prefer then to their *Mallets*.

Twelve-coupled locomotives are exceptional [3] though they can be used both

(1) These locomotives take curves well; the 1st, 3rd and 6th pair of coupled wheels have lateral play.

(2) These locomotives have a speed of 40 km. (25 miles) an hour. Their weight is approximately 17 tons per coupled axle and 15 tons for the others.

The first pair of wheels has a play of 35 mm. (1 3/8 inches) on each side of the central position.

(3) The first twelve-couplers, built in 1857 to the designs of Jame Milholland, were 0-12-0-T banking locomotives of the « Philadelphia and Reading R. R. ». But their design was poor; and as they balked at the curves, it became necessary to uncouple some of the drivers.

It will be remembered that ten years later a like adventure happened with the first Baldwin-built Decapod locomotives.

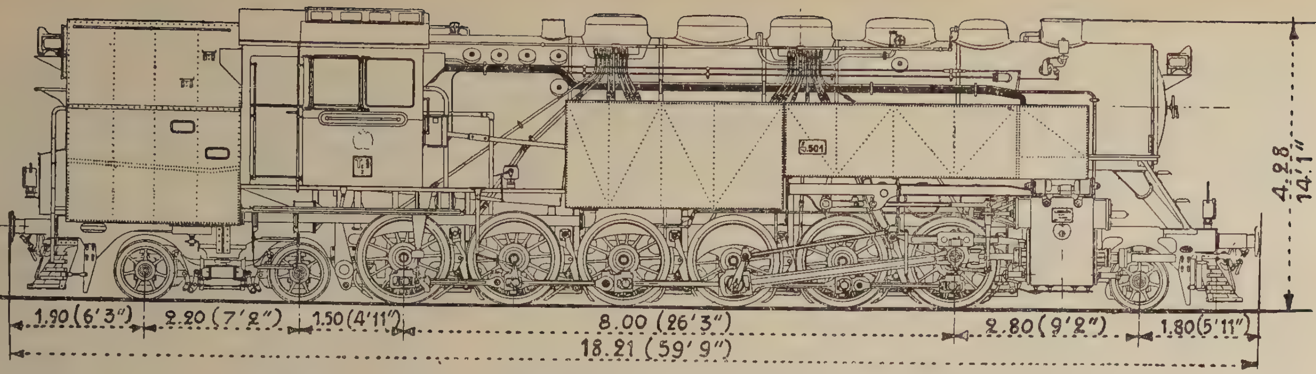


Fig. 253*a*. — 2-12-4-T locomotive of the Bulgarian State Railways. — Elevation.

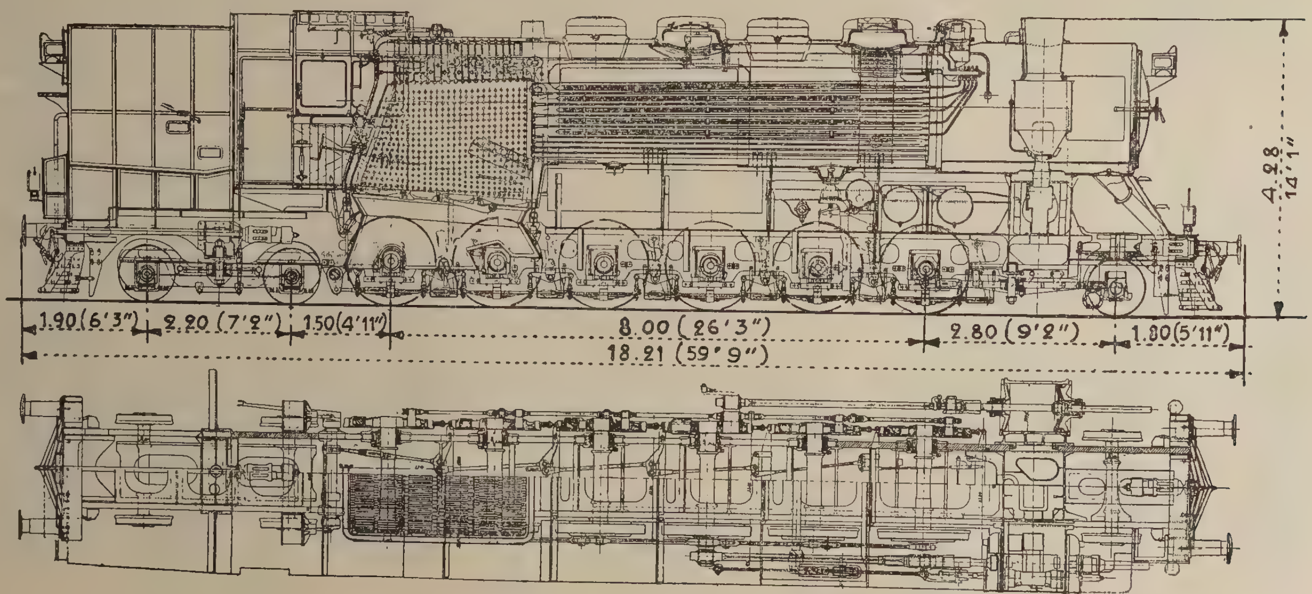


Fig. 253*b*. — 2-12-4-T locomotive of the Bulgarian State Railways. — Longitudinal section and plan.

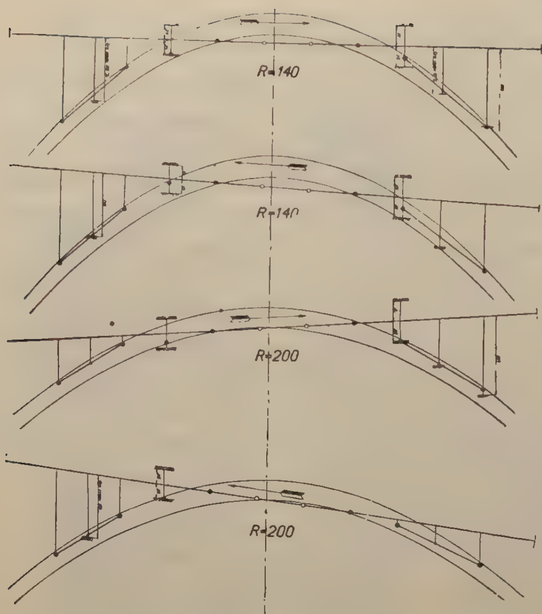


Fig. 254. — 2-12-4-T Bulgarian locomotives. — Diagram showing the position of the axles when negotiating curves.

for mountain express services (usually not exceeding 60 km. = 37.3 miles an hour) and for slower ones.

There are two series in Austria, the first, express 2-12-0 Gölsdorf locomotives dating from 1911 [1], the second, interesting mixed rack and adhesion locomotives of the 0-12-0-T type which we have already dealt with (see pp. 498/440).

The most noteworthy twelve-coupled locomotives are the 33 fine 2-12-0 compounds, built from 1917 to 1924 by the Esslingen Works for the Würtemberg Railways [2], and in the case of 3′ 6″ gauge lines, the « Javanic » 2-12-2 locomotives built by the Hanover Works for the *Javanese State Railways* in 1912 [3].

The only others are those which the *Union Pacific* was able, thanks to the higher axle load, the introduction of the booster, and the improved boiler design, to substitute for *Mallet* locomotives. These 4-12-2 locomotives were built by the *American Locomotive Company* to replace, with equal power, the 2-8 + 8-2 at the speeds of the 2-10-2, which usually reached 60 miles an hour in service [4].

Only the U. S. S. R. went further in this direction, and produced 14-coupled

(1) The first two pairs of wheels are grouped in one bogie of the Krauss-Helmholtz type. In addition, the 3rd and 6th pairs of wheels have a lateral play of 25 mm. (1 inch) on either side of their central position and the 4th pair have no flanges. The weight per axle, whether coupled or not, was 13 to 14 tons, the total weight reaching 94.6 t. (93.2 Engl. tons).

These locomotives were intended for fast trains and during the trials, reached a speed of 90 km. (56 miles) an hour. They were used on lines with 1 in 33 gradients.

(2) These locomotives could run through curves of 145 m. (7 1/4 chains) radius. The bissel had a lateral play of 95 mm. (3 3/4 inches), the 1st and 4th coupled wheels, of 20 and 45 mm. (13/16 and 1 3/4 inches). The flanges of the 3rd and 4th pairs of wheels were tapered to a thickness of only 15 mm. (5/8 inch).

The weight per axle was 15.6 to 15.8 t. (15.3 to 15.5 Engl. tons), the adhesive weight 93.6 t. (92.2 Engl. tons), and in working order the total weight of the locomotive was 106.6 t. (105.0 Engl. tons).

(3) The outer coupled wheels had a lateral play of 30 mm. (1 3/16 inches) each side of the central position.

(4) These three-cylinder locomotives have an adhesive weight of 160.8 t. (158.2 Engl. tons) and a total weight of 224 t. (220.4 Engl. tons), and can develop a tractive effort of 43 800 kgr. (96 650 lb.). The 12-wheeled tenders have a capacity of 21 tons of fuel and 15 000 gallons of water. They weigh 131 t. (128.9 Engl. tons) in working order.

express « mineral » locomotives for the Donetz lines (1).

The necessity arose in the U. S. S. R., as everywhere else, to work heavy trains,

TABLE 239.

LEADING DIMENSIONS OF RECENT POWERFUL SOVIET LOCOMOTIVES.

Type of locomotive / Builder / Date built	4-8-2+2-8-4 Beyer-Peacock. 1933.		4-14-4 (2) Lugansk. 1934.	
Cylinders	0.570 × 0.710 m.	22.4″ × 27.95″	740 × 810 mm.	29 1/8″ × 31 7/8″
Boiler, height of centre line above rail level	3 m.	9′ 10″	3.65 mm.	11′ 11 3/4″
Pressure	15 at.	220 lb.	17 kgr./cm²	242 lb.
Firebox	...	...	4.8 × 2.5 mm.	15′ 9″ × 8′ 2 7/16″
Combustion chamber, length	...	...	2.5 m.	8′ 2 7/16″
Tubes, number	246 and 60		138 and 48	
Do. diameter	136.5 and 50.8 mm.	5.25″ and 2″	69.8 and 171.4 mm.	2 3/4″ and 6 3/4″
Do. length	4.65 m.	15′ 3 1/16″	7 m.	22′ 11 9/16″
Heating surface, firebox	31.4 m².	338 sq. ft.	55.2 m²	594.4 sq. ft.
Do. total	331.1 m².	3 564 sq. ft.	448.0 m²	4 822.7 sq. ft.
Superheater	112 m².	1 205.6 sq. ft.	174.0 m²	1 872.9 sq. ft. (Chussof).
Boiler horse power	...	...	4 000 C.V.	3 880 H. P. (Cook).
Tractive effort (2)	35 680 kgr., 75 %.	78 700 lb., 75 %	40 000 kgr., 85 %	88 250 lb., 85 %
Length over buffers	33.23 m.	109′	33.73 m.	110′ 8″
Overall height	5.23 m.	17′ 2″	...	...
Wheelbase. rigid	4.953 m.	16′ 3″	10.20 m.	32′ 11 5/8″
Do. total locom.	30.075 m.	98′ 8″	17.320 m.	56′ 9 7/8″
Do. tender	...	...	9.10 m.	29′ 10 1/4″
Diameter of carrying wheels	0.94 and 1.02 m.	3′ 1″ and 3′ 5″	0.76 and 1.05 m.	2′ 5 15/16″ — 3′ 5 5/16″
Do. coupled wheels	1.50 m.	4′ 11″	1.60 m.	5′ 3″
Water capacity	37 m³.	1 306 cu. ft.	43.9 m³	11 620 gall. U. S.
Coal capacity	16 t.	...	21.7 t.	24 short tons
Adhesive weight	152 t.	...	...	...
Total weight	259 t.	...	297 t.	328 short tons
Maximum speed	72 km./h.	45 m.p.h.	...	...

(1) These locomotives are derived from the Wurtemberg locomotives. The rigid wheel base was increased from 7.50 m. to 10.13 m. (from 24 ft. 7 9/32 in. to 33 ft. 3 in.) which has increased the minimum radius of curves by 1 chain) from 145 to 165 m. (from 7 1/4 to 8 1/4 chains).

(2) From *The Railway Mechanical Engineer.*

the more so that most of the lines are single-tracked with crossing loops long distances apart. Now, capacity goes hand in hand with train tonnage and frequency. As Soviet track is light as a rule, locomotives with the highest possible number of coupled wheels were resorted to. The Lugansk Locomotive Works were thus led to build engines with 14 coupled wheels, which are shown in figure 255. This is the highest number of coupled wheels ever used in a non-articulated locomotive design. It seems interesting, therefore, to compare their leading dimensions with those of the heaviest *Garratt* locomotives, built by the Beyer-Peacock Works, Manchester (table 239).

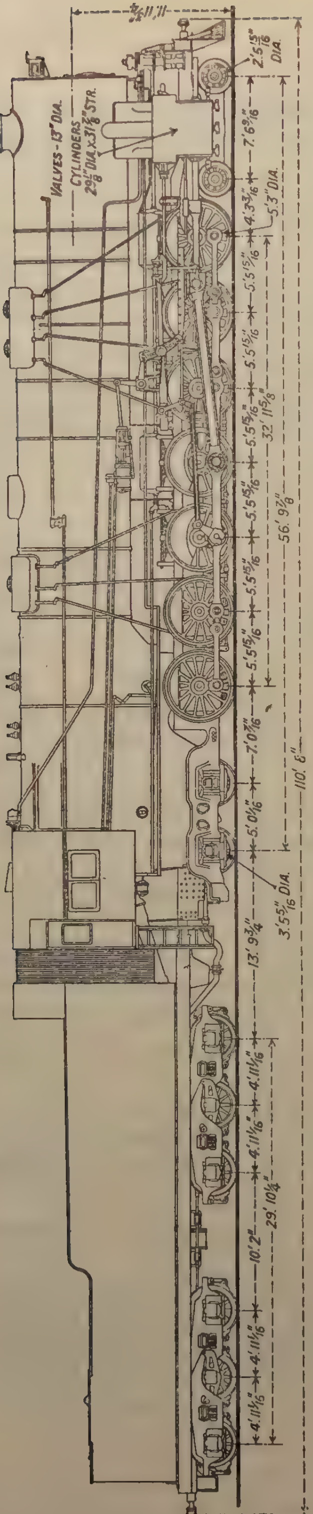


Fig. 255. — Non-articulated 4-14-4 locomotives of the *Soviet Railways*, built by the Lugansk Works.

(From *The Railway Mechanical Engineer.*)

XL-3. — **Railways in Turkey in Europe**, operated by the *Oriental Railways Co.* now only consist of a 289-km. (179.6 miles) stretch of main line from the Greek frontier to Istanbul (1) and a couple of branches, 46 and 3 km. (28.6 and 1.9 miles) long respectively (2) (fig. 256).

The common origin, however, of most of the great Balkan lines is still noticeable in the number of factors which still affect them all to-day (3).

(1) Maximum gradients 1 in 67.

(2) The distances are :

Istanbul	0	
Yechitkeuy . . .	17.951 km.	(11.16 miles).
Mandra—Branch line 45.6 km. long to Kirkhar Eli.		(28.20 miles).
Frontier (Maritza)	280.982 km.	(174.60 miles).
Pythion	282.258 km.	(175.30 miles).
Frontier	313.681 km.	(194.91 miles).
Odrin	318.286 km.	(197.18 miles).
Branch 3 013 m.	(1.87 miles) long.	
Frontier (bridge)	320.817 km.	(199.35 miles).
Bulgarian frontier	351.129 km.	(218.20 miles).
Svilengrad . . .	355.024 km.	(220.61 miles).

(3) See « Les Chemins de fer de la Turquie d'Europe et des Etats successeurs » (The railways of Turkey in Europe and the Successor States), by the same author.

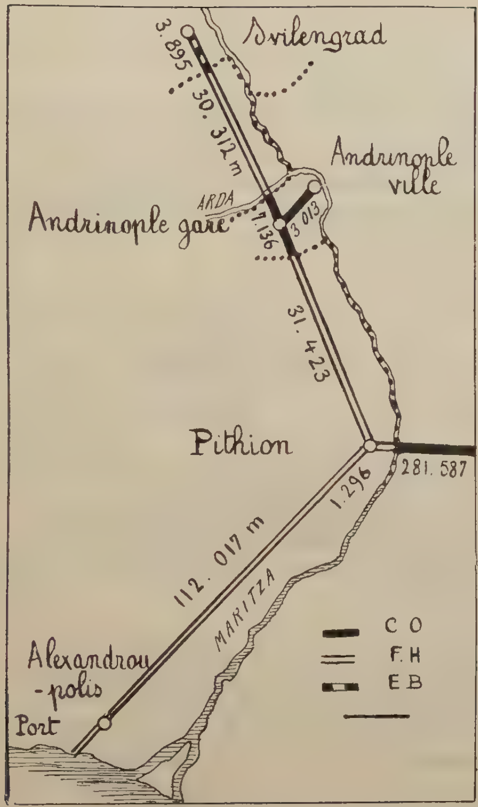


Fig. 256. — Diagram showing the railways on the frontiers of Greece, Bulgaria and Turkey.

Legend:

C.O. = Oriental (Turkish) Railways.
F.H. = Greek Railways.
E.B. = Bulgarian State Railways.

In addition to the general scheme in connection with the layout of the system which was eventually to link up the Balkan capitals to each other and to Western Europe, the time limits of the various works, the rates to be applied, the circulation of trains, etc... were all laid down in a series of agreements. The « Treaty of Berlin », 1878, having laid the foundation, the « Convention of the Four Powers », signed on the 9th May 1883, between Turkey, Bulgaria, Serbia and Austria, defined them more explicitly and one practical result was the introduction of the train known as the « Conventional train » between Constantinople and Vienna. This train ran until the War, the « Direct Orient » which starts from Paris having now taken its place.

Through communication was only achieved on the 12th August 1888, but owing to contractual difficulties the last middle section of 46 km. (28.6 miles) between Belovo and Vakarel was only opened to traffic on the 12/24th April 1894.

The rates were based upon virtual distances and are still applied by the *Bulgarian State Rys.* over the original lines and also over the additional lines since built. Table 240 gives some examples.

TABLE 240.

ACTUAL AND TARIFF DISTANCES.

—	Distances	
	Actual Km.	Tariff Km.
Tzaribrod to :		
Kalotino	9.2	4
Dragoman	21.0	21
Kostinbrod	48.5	53
Volouyak	55.6	58
Sofia	63.3	63
Vakarel	102.5	114
Svilengrad	362.4	395
Roussé Port-Gorna Orevitza	113.0	138
Tzareva-Livada	158.3	187
Stara Zagora	265.1	309
Sofia-Doupnitza	90.7	112
Pleven-Somovit	40.1	50

XL-4. — **The International Sleeping-Car Company's trains.** — The crack trains connect Istanbul and Bucharest with the western capitals.

The « Orient Express » ran for the

TABLE 241.

INTERNATIONAL SLEEPING-CAR CO. TRAINS TO THE NEAR EAST AND ISTANBUL.
(Obsolete trains shown *in italics*).

Origin.	ROUTE.	Actual distance. Km.	Actual distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Date.
	Orient Express.							
Paris Est.	*Munich - Vienna - Bucharest - Roussé-Varna*	3 174	1 972.3	*6.50* p. m.	*79.10*	*40.1*	*24.9*	In 1890.
Do.	*Munich-Vienna W. St. Eis.-Sofia*	3 014	1 872.8	*7.08* p. m.	*61.31*	*51.4*	*31.9*	In 1902.
Do.	*Munich - Vienna - Timisoara - Constanza*	3 145	1 954.2	*Do.*	*62.22*	*50 5*	*31.4*	Do.
Calais Mar.	*Paris E - Munich - Arad - Constanza*	3 449	2 143.1	*3.10* p. m.	*72.50*	*47.3*	*29.4*	In 1929.
Do.	Châlons-Munich-Sofia	3 333	2 071.1	5.25 p. m.	61.20	54.3	33.7	In 1934.
Paris Est.		3 124	1 941.2	7.55 p. m.	58 50	53.1	33 0	Do.
Berlin Fr.	*Breslau-Galanta-Budap.-Sofia*	2 413	1 499.4	*8.00* a. m.	*48.39*	*46.1*	*28.6*	*Berlin-Buda-pest-Orient* (1902).
	Ostend-Vienna Express.							
Ostend Q.	*Cologne-Vienna W.-St. Eis-Sofia*	3 281 (1)	2 038.8 (1)	*4.46* p. m.	*63.53*	*51.4*	*31.9*	In 1902.
Calais Mar.		3 388	2 105.2	*12.47* p. m.	*67.52*	*48.3*	*30.0*	*Do.*
Ostend Q.	Do.	3 399 (2)	2 112.1 (2)	8.32 p. m.	56.13	57.5	35.7	In 1935.
Amsterdam.		3 187	1 980.3	7.41 p. m.	56.29	56.6	35.2	Do.
	Arlberg-Orient Express.							
Paris Est.	Laon-Basle-Arlberg-Sofia	3 174	1 972.3	7.55 p. m.	57.50	54.9	34.1	In 1935.
Calais Mar.		3 383	2 102.1	5.25 p. m.	60.20	55.8	34.7	Do.
	Simplon-Orient Express.							
Calais Mar.	*Paris-P.L.M.-Milan-Sofia*	3 395	2 109.6	*2.55* p. m.	*88.05*	*38.5*	*23.9*	In 1924.
Do.	Paris N.-P.L.M.-Milan-Sofia	3 401	2 113.3	2.30 p. m.	63.15	53.8	33.4	In 1935.
Prague Mas.	Galanta-Budapest-Sofia	2 045	1 270.7	1.50 p. m.	40.01	51.1	31.8	Isolated carriage (1935).
Berlin Schl.	Breslau-Bohumin-Galanta-Sofia	2 413	1 499.4	8.14 a. m.	46.41	51.7	32.1	Do.
Berlin Anhalt.	Prague-Budapest-Sofia	2 418	1 502.5	7.55 a. m.	46.50	51.6	32.0	Do.

first time between Paris and Vienna on the 1st June 1883. Soon afterwards it was extended as far as Constantinople, but as there was still a gap in Bulgaria,

(1) Via the left bank of the Rhine and the old Brussels-Ghent line.
(2) Via the right bank of the Rhine and the new Brussels-Ghent line.

it proceded via Bucharest-Giurgiu to Varna, where passengers took a steamer to the Turkish capital. The two Bulgarian sections of the railway having at last been linked up, through connection was established through Bulgaria in 1894 and trains run from Vienna to Belgrade, Sofia, and so to Constantinople (Istanbul) but the Rumanian section was retained, the port of embarkation being shifted from Varna to Constanza.

The « Ostend-Vienna Express », introduced soon afterwards, was also extended, and through coaches from this train attached to the « Orient Express » by both the Bucharest and the Sofia routes.

Towards 1906, a Berlin train was added, running via Breslau and Galanta, where it joined the route of the « Orient Express ». This was the short-lived « Berlin-Budapest-Orient Express ».

After the War, Istanbul was reached by means of an extended « Simplon Express », besides the more recent « Arlberg-Orient Express ».

In this way the Company's three Eastern trains : the « Orient Express » (including the « Ostend-Vienna »), the « Arlberg-Orient » and the « Simplon-Orient » frequently crossed each other's routes. The latter became the more prominent, sleeping cars from many places were included in it, and it has been extended into Asia.

Table 241 gives information concerning each of these trains, applying to each of the routes they successively followed. In both tables 238 and 241 we have not given the generally quoted mileages. We have added the actual mileages of each of the countries run through, as given by the Railway Administrations concerned, and if need be have corrected them as in the case of the distances between Brussels and Ostend, those between Paris (or Vienna) terminals, and elsewhere, using actual instead of tariff mileages, as in Switzerland, Austria, Bulgaria and Turkey and distances across some of the longer Hungarian bridges.

XII. — RUMANIA.

SUMMARY.

CHAPTER XLI.

CHAPTER XLI.

XLI-1. — **General.** — This system is very centralised, all express train lines without exception radiating from Bucharest towards the frontiers, where they ensure international connections.

Whilst the greater part of the old Kingdom was flat, this is not true of new Rumania where the Transylvanian Alps have peaks reaching up to more than 2 500 m. (8 200 feet) above sea level (the Negoiul, 2 542 m. = 8 340 feet) and can only be crossed by certain passes which in many cases are 1 900 m. (6 235 feet) above datum. The Moldavian Carpathians are not as high and the passes lower, 500 to 600 m. (1 640 to 1 970 feet) only. In their widest part, in Bukovina, they include the Rodna group (2 300 m. = 7 550 feet) high, and in the West, the Bihor group (1 500 to 1 700 m. = 4 920 to 5 580 feet).

The **Rumanian railway system** now includes 10 498 km. (6 523 miles) of standard-gauge and 716 km. (445 miles) of metre or narrow-gauge lines.

The loading gauge of the narrow-gauge lines is 2.50 m. (16 ft. 2 1/2 in.) wide and 3.50 m. (22 ft. 5 3/4 in.) high.

Heavy gradients are to be met with on several of the mountain lines, such as the Ploesti-Brasov (on the international Budapest-Bucharest route) and the Darmanesti-Vatra Dornei-Dornisoara lines, both of which rise to a height of over 1 000 m. (3 280 feet) above sea level [1]. Gradients on the latter reach 1 in 34 between Cacica and Paltinoasa.

The Caransebes Subcetate railway, through the Portille de fer is steeper still, but here a rack is used on both sides of the pass, (29th mile, altitude 2 270 feet), gradients reaching 1 in 20 upwards between Boutari-Portille de fer and downwards to Sarmisegetuza.

The **times** given are those of the 1935 Summer timetables; many trains have been speeded up as from the 15th May 1935.

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(1) These are the heights above datum of the principal points on the latter line :

	Km.	Miles.	Metres.	Feet.
Darmanesti	0	0	+ 294	975
Mestecanis	92	57.2	949	3 114
Dorna bridge	116	72.1	813	2 627
Dornisoara	139	86.4	1 031	3 383

Fig. 257. — Railways in the Rumano-Czechoslovak frontier region.
And (heavy line) Rumano-Czechoslovak joint railway.

XLI-2. — **Frontier sections.** — Rumania suffered less than some of the other States from the awkward way the new frontiers were laid out and the Czechoslovak and Jugoslav frontiers alone show any oddities.

A Rumanian line links up Oradea Mare with Halmei and Kralovo (a Czechoslovak town), Camara la Sighet (Rumania) and the North-East of the country (fig. 257). On the other hand, the latitudinal Galician line joins it at Kralovo and splits away from it at Valea

TABLE 242.

FRONTIER SECTIONS OF THE INTERNATIONAL LINES.

Origin.	FRONTIER SECTION. Places.	Length Km.	Length Miles.	Destination.	Operating Administration.
	To Bulgaria.				
Medgidia.	Bazargie (stops, then) Oborichté.	20	12.4	Varna.	Rumanian.
Bucharest.	Giurgiu-Roussé	...	...	Sofia.	Shipping Co.
	To Jugoslavia.				
Timisoara	Stamora Morav (Voiteni, 13th km.), Vrsac	19	11.8	Bazias.	Jugoslav.
Do.	Bela Crkva-Bazias	13	8.1	Do.	Do.
Do.	Cruceni-Iasa Tomic	3	1.9	B. Alexandrovo.	...
Do.	Jimbolia-Velika Kikinda . . .	20	12.4	Subotica.	Do.
	To Hungary.				
Arad.	Pecita-Battonya	14	8.7	Szegel.	Rumanian.
Do.	Decebal-Lököshaza	11	6.8	Budapest.	Hungarian.
Do.	Solonta- Kötegyan	14	8.7	Bekescsaba.	Rumanian.
Oradea.	Episcopia Bihor.-Biharkeresztes .	13	8.1	Budapest.	Hungarian.
Do.	Valea Lui Mihai (stop, then) Nyirabrany	9	5.6	Debrecen.	Rumanian.
	To Czechoslovakia.				
Do.	Halmei-Dakovo	4	2.5	(Kralovo).	Czechoslovak.
	Do. -Teresva-Dragos Voda . .	6	3.7	Stanislawow.	Do.
	Do. -Valea Viseului-Trebusany.	4	2.5	Do.	Rumanian.
	To Poland.				
Cernauti.	Gr. Ghica VodaESniatyn-Zalucze .	10	6.2	Lwow, etc.	Rumanian.
Do.	Stefanesti-Schit-Zaleszczyki . .	2	1.2	...	Rumanian.

Visaului so as to proceed northwards. Instead of duplicating this section on both sides of the frontier, it was decided that the part of the railway between Halmei and Valea Visaului should become the joint property of the Rumanian and Czechoslovak Governments, who would operate it as a joint concern, although the first part, from Halmei to Kralovo and Teresva (74 km. = 46 miles) lies in Czechoslovakia, and the rest, from Teresva to Camara la Sighet and Valea Visaului (43 km. = 26.7 miles), in Rumania. The total length of the joint section is thus 117 km. (72.7 miles) (1). This is, we think, the only instance on the Continent, where a solution has been applied so as to reconcile opposing interests, although it is often to be found in great Britain.

Beyond Valea Visaului (272nd km. = 169th mile after Oradea) the Czechslovak line serves the town of Zimir (327th km. = 203rd mile) before reaching the country's southern frontier. It then continues towards the Rumanian town of Gregorio Ghica Voda after a run of 10 km. (6.2 miles) under Polish administration.

There is an equally curious state of affairs in the South West of the country (fig. 242). The railway from Timisoara reaches the Rumanian town of Bazias (120 km. = 75 miles) after running 53 km. (32.9 miles) through Jugoslavia, between the 56th km. (34.8th mile) (Stamora Morav) and the 107th (66.5th mile) (Bela Crkva).

To bring out more clearly the railway distances affected by these complicated frontier questions, table 242 quotes data concerning these international section :

2, towards Bulgaria,
4, towards Jugoslavia,
5, towards Hungary,
3, towards Czechoslovakia,
3, towards Poland, and
none towards Russia.

XLI-3. — **Bridges over the Danube.** — The Constanza line crosses the Danube by the famous Carol I bridge, which was built between 1890 and 1894, and is 40 m. (131 feet) above high water level (2). This is the last bridge over the Danube. The others have the lengths shown in table 243.

XLI-4. — **Rumanian train speeds.** — Interesting runs are given in tables 245 and 246 and the maximum commercial (overall) speeds of the different express lines of the system are shown in the cartogram, figure 258. As in nearly all Eastern European countries, most of these are accomplished by *International Sleeping-Car Company* trains. Of the

(1) Kralovo is 177 km. (110 miles) from Oradea; Dragos Voda 235 km. (146 miles), and Sigetul Marmatiei 245 km. (152.2 miles). The Rumanian expresses terminate here.

(2) After crossing the western arm of the river, the railway runs over a viaduct 650 m. (2 132 feet) long, and an embankment of 13 km. (8.1 miles) through the Balta Island, followed by a viaduct 900 m. (2 955 feet) long (15 arches 60 m. = 197 feet long).

The main bridge is composed of 5 spans of 190 m. (624 feet) and 4 outer spans of 140 m. (459 feet), altogether 1 510 m. (4 956 feet). The lake of Czernavoda which is connected to the river, is 35 km. (21.7 miles) long and 2 to 4 km. (1.2 to 2.4 miles) wide.

eight « RAPIDES », all starting from Bucharest N., five belong to this Company. Two of them reach commercial speeds of over 80 km. (49.9 miles) an hour over part of the journey.

TABLE 243.

BRIDGES OVER THE DANUBE.

BRIDGE.	Number of spans.	Total. Metres.	Total. Feet.
Austria.			
Linz-Urfahr Verbindungsbahn (1)	3+ 4 (2)	399.7	1 311
Steyregg (Linz-Gaisbach)	5+ 2	452.6	1 484
Mauthausen (St. Valentin-Summerau)	5+ 3	493.5	1 619
Krems	4+17	683.1	2 241
Tulln (Vienna-Gmund)	5+17	697.1	2 287
Vienna NW (Grusbach)	5+15	883.9	2 900
Vienna N (Bernhardstal)	4+13	848.8	2 784
Ostbahn Stadlau (Laa a.d.Th.)	4+19	857.7	2 814
Hungary.			
Baja-Battaszek		576	1 890
Budapest (3)		476	1 562
Ujpest		673	2 208
Yougoslavia.			
Novi Sad (Belgrade-Subotica)		432	1 417
Bogojevo (Vinkovci-Subotica)		619	2 030
Belgrade (Belgrade-Pancevo)		1 391	4 563
Orsova (Belgrade-Bucharest, projected)		800 to 1 250	2 625 to 4 100
Rumania.			
Borcea		970	3 182
Ezer		1 455	4 177
Regele Carol I		1 663	5 456

The speed of the (« accel ») expresses is not much lower than that of the « rapides ».

Out of the whole standard-gauge system (10 498 km. = 6 523 miles) :

212 km. (132 miles) i.e. 2 % are run over

(1) Rail and road bridge.

(2) Stromöffnung + Flussoffnung (number of bays over the river, plus number of high-water bays).

(3) The road bridges of Budapest are shorter. That of the Margaret Island is 400 m. (1 312 feet) long; the suspended bridge, 488 m. (1 600 feet) long, is divided up into a central part of 298 m. (978 feet) and two lateral bays of 95 m. (311 feet).

at overall speeds of between 80 and 89.9 km. (50 and 55.9 miles) an hour;

802 km. (498 miles), i.e. 7.6 % at overall speeds of from 70 to 79.9 km. (43.5 to 49.9 miles) an hour;

1 062 km. (660 miles) i.e. 10.1 % at overall speeds of 60 to 69.9 km. (37.5 to 43.4 miles) an hour;

8 422 km. (5 233 miles) i.e. 80.3 % at less than 60 km. (37.5 miles) an hour overall speed.

FUEL. — Fast trains burn Golesti or Doicesti lignite improved by oil fuel, whereas goods train locomotives burn washed Petrosani coal in the mountains. Apart from this, a variety of fuels is used, whose main characteristics are as hereafter :

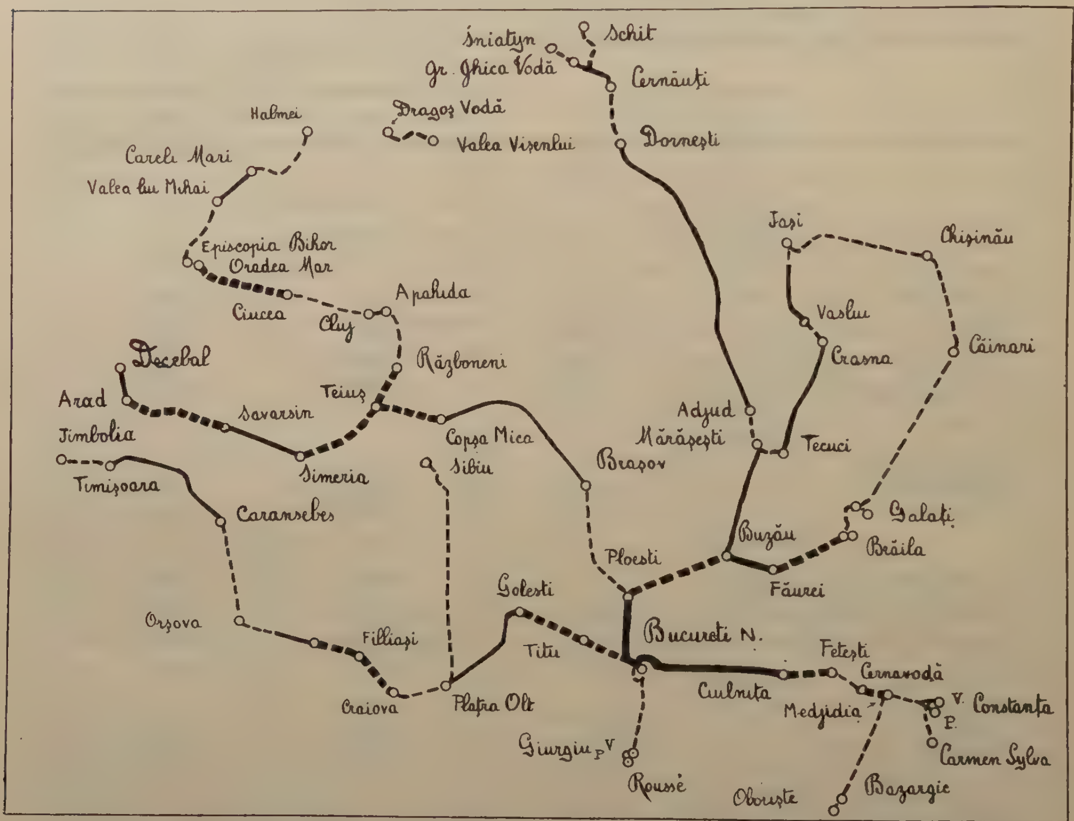


Fig. 258.— Cartogram showing the maximum overall speeds of Rumanian trains, on all express train routes.

(thick solid line)	50 to 55.9 m. p. h.
(thick dashed line)	43.5 to 49.9 m. p. h.
(thin solid line)	37.5 to 43.4 m. p. h.
(thin dashed line)	under 37.5 m. p. h.

KIND OF FUEL.	Evaporating power.	Calorific power. B.T.U./lb.	Ash.
Oil fuel.	9.4	17 640	
Coal.			
Petrosani { washed / briquettes }	6.3	12 060	8 %-12 %.
Lones	6.1	11 700	8 %-12 %.
Anina { coal	6.0	11 500	Do.
Anina { briquettes	6.7	13 150	Do.
Cr. Carb. { screened / briquettes }	5.2	9 000	12 %-16 %.
Codlea, briquettes	5.0	8 650	12 %-16 %.
Cozla	5.0	8 650	12 %-16 %.
Surduc, screened	4.9	8 650	12 %-16 %.
Sorecani, screened	4.8	8 650	12 %-16 %.
Jibou	4.7	8 650	12 %-16 %.
Lapos	4.5	8 650	12 %-16 %.
Salatruc	4.2	8 100	12 %-16 %.
Improved lignite.			
Schitul Golesti	...	6 300	18 %.
Doicesti	...	5 760	18 %.

TABLE 244.

FAST RUMANIAN TRAINS.

(Discontinued trains are shown *in italics*).

RUN FROM BUCHAREST NORTH TO	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Name of train.
Timisoara - Jimbolia (Paris P.L.M.)	614	381.5	9.25 a. m.	10.10	55.8	34.7	Rap. Simplon.
Timisoara	575	357.3	*1.15* p. m.	*10.41*	*53.8*	*33.4*	*Rap. Traian* (1).
Episcopia Bihor. (Budapest)	660	410.1	2.00 p. m.	11.58	55.0	34.2	R. Ardeal (Arlberg).
Brasov	170	105.6	5.50 p. m.	3.30	48.6	29.8	Rap. Carpati.
Arad-Lököshaza-Decebal (Boulogne and Ostend)	656	407.6	7.15 p. m.	10.27	62.6	38.9	Luxe (Orient-Exp.).
Arad-Decebal (Budapest)	647	402.0	8.05 p. m.	11.28	55.9	34.7	Rap. Dacia.
Gr. Ghica Voda (Prague and Warsaw)	563	349.8	9.40 a. m.	9.08	61.6	38.3	Rap. Stefan cel Mare.
Chisinau (Kichineff)	539	334.9	*7.10* a. m.	*9.00*	*59.9*	*37.2*	*Rap. Unirea (Union)* (1).
Galati	260	161.6	7.00 p. m.	3.45	69.3	43.1	Rap. Danubiu.
Constanza	227	141.0	6.40 p. m.	3.13	70.6	43.9	Fulger Regele Carol. I.
Do.	227	141.0	—	*3.30*	*65.0*	*40.4*	*Rap. Tomis* (2).

(1) 1931 timetable. — (2) 1932.

TABLE 245.

NOTEWORTHY RUMANIAN TRAIN SPEEDS (1935 Summer).

(Obsolete services are shown in *italics.*) — (Non-stop runs in **heavy** type.)

RUNS.	Distance.		Time of departure.	Time spent.	Speed.		Number of stops.	Name of train.
	Km.	Miles.			Km./h.	Miles/h.		
Bucharest N. - Timisoara - Jimbolia	614	381.5	9.25 a. m.	10.10	60.4	37.5	17	Rap. Simplon.
Bucharest N.-Titu	**48**	**29.8**	**7.50 p. m.**	**0.54**	**53.3**	**33.1**	—	Do.
Chitila-Titu	**38**	**23.6**	**9.37 a. m.**	**0.31**	**73.6**	**45.7**	—	Do.
Titu-Pitesti	**60**	**37.3**	**10.09 a. m.**	**0.50**	**72.0**	**44.7**	—	Do.
Lugoj-Timisoara-Fabrica	**57**	**35.4**	**6.08 p. m.**	**0.47**	**75.3**	**46.8**	—	Do.
Craiova-Filiasi	**36**	**22.4**	**1 28 p. m.**	**0.26**	**83.1**	**516.4**	—	Do.
Bucharest N.-Teius-Arad-Decebal (1)	647	402.0	7.15 p. m.	10.27	61.9	38.5	15	Orient Express.
Bucharest N.-Arad	630	391.5	8.05 p. m.	11.28	55.9	34.7	31	Rap. Dacia.
Do. -Brasov	170	105.6	5.50 p. m.	3.30	48.6	30.2	10	Rap. Carpati.
Do. -Ploesti Vest	**63**	**39.1**	**5.50 p. m.**	**0.47**	**80.5**	**50.0**	—	Do.
Do. -Ploesti S.	**59**	**36.7**	**R11.50 p. m.**	**0.50**	**70.8**	**44.0**	—	Pers.
Copsa Mica-Simeria	*125*	*77.7*	*6.38 a. m.*	*R 1.46*	*70.7*	*43.9*	—	*Orient Express (1).*
Micasasa-Simeria	*113*	*70.2*	*12.23 a. m.*	*1.36*	*70.1*	*43 5*	—	*Do. (1).*
Bucharest N. - Brasov - Oradea Mare-Sig. Marmmotel	926	575.4	11.00 p. m.	17.55	—	—	47	To Prague.
Bucharest N. - Oradea - Episcopia Bihor	654	406.4	2.00 p. m.	11.58	54.5	33.9	28	Rap Ardeal (Arlberg
Teius-Rasoboieni	**33**	**20.5**	**9.36 p. m.**	**0.27**	**73.6**	**45.7**	—	Do.
Ciusea-Oradea Mare	**80**	**49.7**	**12.41 a. m.**	**1.05**	**73.8**	**45.8**	—	Do.
Bucharest N.-Panciu-Gr. Ghica Voda	563	349 8	9.40 a. m.	9.08	56.3	35.0	16	Rap. Stefan cel Mare.
Ploesti S.-Buzau	**69**	**42.9**	**10.29 a. m.**	**0.55**	**75.3**	**46.8**	—	Do.
Bucharest N.-Jasi-Chisinau	*537*	*333.7*	*7.10 a. m.*	*9.00*	*59.7*	*37.1*	*10*	*Rap. Unirea (1932).*
Jasi-Chisinau	**131**	**81.4**	**1.56 p. m.**	**2.14**	**50.8**	**31.6**	—	*Do.*
Bucharest N.-Buzau-Galati	260	161.6	7.00 p. m.	3.45	69.3	43.1	4	Rap. Danubiu.
Buzau-N. Filipescu (2)	**40**	**24.9**	**8.53 p. m.**	**0.30**	**80.0**	**49.7**	—	Do.
(Bucharest N.) N. Filipescu (3)-Braïla	**60**	**37.3**	**9.25 p. m.**	**0.44**	**81 8**	**50.8**	—	Do.
Bucharest N.-Buc. E.-Constanza	227	141.1	6.40 p. m.	3.13	70.6	43.9	4	Fulger Regele Carol.
Bucharest N.-Ciulnita	**109**	**67.7**	**6.40 p. m.**	**1.18**	**83.8**	**52.1**	—	Do.
Ciulnita-Fetesti	**38**	**23.6**	**7.32 p. m.**	**0.30**	**76.0**	**47.2**	—	Do.
Cernovada-Medgidia	**24**	**14.9**	**9.00 p. m.**	**0.19**	**75.8**	**47.1**	—	Do.
(Bucharest N.)-Piatra Olt-Sibiu	186	115 6	R 8.45 p. m.	4.29	41.1	25.5	14	Accelerated (Transverse line).

(1) Up to and including the 1935 Winter.
(2) Decebal was formerly called Curtici.
(3) As from and including the timetable for the 1935 Summer, Flaurei has been renamed N. Filipescu.

TABLE 246.

NOTEWORTHY RUMANIAN NON-STOP RUNS.

RUNS.	Distance.		Time of departure.	Time spent.	Speed.		Name of train.
	Km.	Miles.			Km./h	Miles/h.	
Fastest trains.							
Bucharest N.-Ciulnita (Constanza) .	109	67 7	6.05 p. m.	1.18	83.8	52.1	Fulger Regele Carol I.
(Bucharest N.) Craiova-Filiasi (Timisoara)	36	22.4	1.28 p. m.	0.26	83.1	51.6	Rap. Simplon.
(Bucharest N.) Filipescu-Braïla (Galati)	60	37.3	9.25 p. m.	0.44	81.8	50.8	Rap. Danubiu.
Bucharest N.-Ploesti Vest	63	39.1	5.50 p. m.	0.47	80.5	50.0	Rap. Carpati.
(Bucharest N.) Buzau-N. Filipescu (Galati)	40	24.8	8.53 p. m.	0.30	80.0	49.7	Rap. Danubiu.
(Bucharest N.) Ciulnita-Fetesti (Constanza)	38	23.6	7.32 p. m.	0.30	76.0	47.2	Fulger Regele Carol I.
(Bucharest N.) Cernavoda-Medgidia (Constanza)	24	14.9	9.00 p. m.	0.19	75.8	47.1	Do.
(Bucharest N.) Lugoj-Timisoara . . .	59	36.7	6.08 p. m.	0.47	75 3	46.8	Rap. Simplon.
(Do.) Ploesti Sud - Buzău (Gr. Ghica)	69	42.9	10.29 a. m.	0.55	75.3	46.8	Rap. Stefan cel Mare.
Longest runs.							
(Bucharest) N.) Jasi-Chisinau . .	131	81.4	*1.56* p. m.	*2.14*	*50.8*	*31.6*	*Rap. Unirea.*
(Do.) *Brasov-Sighisoara* (1).	128	79.5	*9.20* p. m.	*1.56*	*66.2*	*41.1*	Orient Express.
(Do.) *Copsa Mica - Simeria* (1)	125	77.7	*6.38* a. m.	R*1.46*	*70.7*	*43.9*	Do.
Bucharest N.-Ciulnita (Constanta) .	109	67.7	6.05 p. m.	1.12	83.8	52.1	Fulger Regele Carol I.
(Bucharest N.) Simeria-Varadia . . (Arad)	82	51.0	3.12 a. m.	1 08	72.3	44.9	Orient Express.
(Bucharest N.) Ciucea-Oradea Mare.	80	49.7	12.41 a. m.	1.05	73.8	45.9	Rap. Ardeal. (Arlberg Express).
(Do.) Varadia-Arad . .	76	47.2	4.21 a. m.	1.03	72.4	45.0	Orient Express.

(1) Until the 15th May 1935.

Railcar services. — Many routes formerly served only by slow trains, are now worked by railcars.

The Rumanian Railways have recently ordered a certain number of fast diesels, with a maximum speed of 120 km. (75 miles) an hour ([1]) (fig. 259).

XLI-5. — **International lines.** — In former days, Bucharest was merely a Balkan capital through which trains from the West to Constantinople ran, but since the War, the position has greatly altered, and the services to and from Bucharest are now as important as the Istanbul ones.

Between Bucharest and Budapest there are three main lines whose lengths now differ by some 20 km. only :

Via	Km.	Miles.
Timisoara-Szeged . . .	880	546.8
Arad-Szolnok	883	548.7
Oradea Mare-Debrecsen .	903	561.1

The first of these, the most southerly, crosses the mountains at a lower level than the others, the highest point (533 m. = 1 814 feet above sea level) being attained at Teregova. Before the War the Rumanian branch of the « Orient Express » followed this route which it has now given up to avoid crossing a corner of Jugoslavia for some 90 km. (56 miles) between Szöreg and Jimbolia. Against this, the « Simplon Orient Express » coming from the latter country rejoins the abandoned route at Jimbolia and follows it to Bucharest.

On the other hand, the « Orient Express » now runs over the far more picturesque Szolnok-Arad line, and runs

([1]) Each of the 2 bogies is fitted with a 150-h.p. M.A.N. engine with mechanical transmission. The coaches carry 6 second-class and 73 third-class passengers or else 8 and 72 respectively.

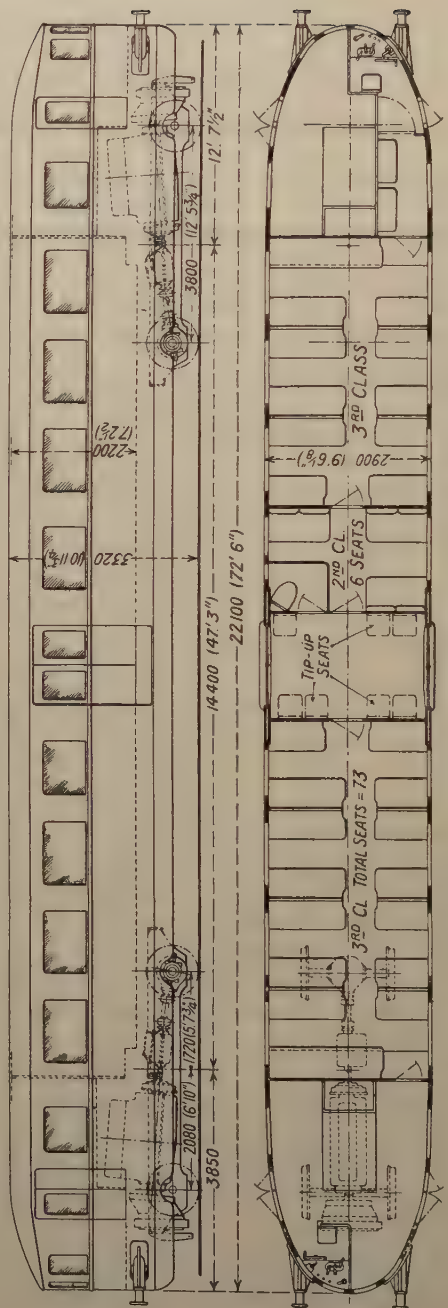


Fig. 259. — *Rumanian State Railways' new diesel railcar.* Reproduced by courtesy of *The Railway Gazette*, London.

through the mountains at twice the altitude of the preceding line. It is proposed to shorten the journey by the building of a new section between Curtea de Arges and Jiblia.

The third and most northerly of the three lines is also a difficult one, and is served by the « Arlberg Express ».

The characterictic gradients and altitudes of these lines are as follows :

—	Distance.		Altitude.	
	Km.	Miles.	Metres.	Feet.
Southern Line.				
Bucharest N.	0	0	...	...
Teregova	533	331.2	...	...
Budapest	880	546.8	...	...
Median Line.				
Bucharest N.	0	0	...	...
Campina	95	59.0	427	1 400
Sinaïa	125	77.7	819	2 687
Predeal (former frontier)	144	89 5	1 054	3 458
The Tomös Pass	154	95.7	707	2 320
Brasov	170	105.6	565	1 854
Border of Transylvania	526	326.8	...	...
Arad	630	391.5	...	...
Decebal (present frontier)	647	402.0	...	...
Szolnok	783	486.5	...	...
Budapest	883	1 548.7	...	...
Northern Line.				
Bucharest N.	...	...	82	269
Teius	400	248.5	243	797
Sardul Clujului	516	320.6	747	2 450
Huedin (1)	552	343.0	544	1 785
Bratca (2)	595	369.7	..	...
The Tileagd Passes	631	392.1	...	...
Oradea Mare	654	406.4	136	446
Episcopia Bihor. (Frontier)	660	410 1	122	400
Budapest	903	561.1	...	...

It is interesting to note that though there are excellent services between Bucharest and the Northern, Central and Western European capitals, communication with the Southern capitals is poor. There are no expresses between Bucha-

(1) Beyond Huedin the line climbs by a series of loops.
(2) The Bihor, a mountain of the Vladeasa group, which rises 1 888 m. (6 195 feet) above sea level, lies immediately to the south.

TABLE 247.

DIRECT CONNECTIONS BETWEEN BUCHAREST AND THE WESTERN CAPITALS. (Fig. 261).

DESTINATION and route followed.	Arrival station.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Name of train.
Berlin.								
Episcopia B.-Budapest-Szob-Prague-Dresden	Anh.	1 883	1 170	R 7.55 a. m.	33.30	56.4	35.0	Arlberg Express.
Decebal-Budapest O. Komaron-Prague-Dresden	Anh.	1 890	1 174	R 1.50 p. m.	39.39	47.0	29.2	
Gr. Ghica-Lwow-Krakau-Breslau	Fr.	1·757	1 092	R 9.20 a. m.	30.15	58.1	36.1	
Vienna.								
Episcopia Bihor-Budapest-Hegyeshalom	Ost.	1 174	730	R 7.10 p. m.	22.15	52.7	32.7	Arlberg Express.
Decebal-Budapest-Hegyeshalom	Ost.	1 154	717	R 11.15 a. m.	22.50	50.5	31.4	Rap. Dacia.
Brussels.								
Grigore Ghica-Lwow-Breslau-Berlin	Nord.	2 539	1 577	R 10.10 p. m.	41.25	61.3	38.1	Rap. Stefan cel Mare and Nord Express.
Decebal-Vienna W.-Cologne	Nord.	2 611	1 622	R 10.10 p. m.	38.05	68.6	42.7	Ostend-Vienna Express.
Paris.								
Gr. Ghica-Lwow-Breslau-Berlin-Cologne	Nord.	2 847	1 769	R 7.15 p. m.	49.56	64.7	40 2	Nord Express.
Episcopia Bihor-Vienna O.-W.-Innsbruck-Basle	Ost.	2 653	1 649	R 2.00 p. m.	45.10	55.1	34.2	Arlberg Express.
Decebal-Budapest W.-Vienna W.-Munich	Ost.	2 572	1 598	7 15 p. m.	40.05	64.3	40.0	Orient Express.
Jimbolia-Vinkovci-Milan-Dijon	P.L.M.	2 695	1 675	R 9.25 a. m.	48.15	55.7	34.6	Simplon Express.
London.								
Decebal-Budapest W.-Vienna W.-Cologne-Flushing	Liv. St.	2 678+306	1 665 + 190	R 10.00 a. m.	50.15	58.1	36.1	Ostend-Vienna Express.
Decebal-Budapest Vienna O. W.-Cologne-Hook of Holland	Liv. St.	2 685+214	1 684 + 133	R 8.30 p. m.	61.25	47.2	29.3	Rap. Dacia.
Gr. Ghica-Voda-Breslau-Berlin-Hook of Holland	Liv. St.	2 537+214	1 576 + 133	R 8.30 p. m.	59.30	46.3	28.8	
Jimbolia-Milan-Paris-Calais	Vict.	3 009+167	1 870 + 104	R 9.25 a. m.	57.00	55.6	34.5	Simplon Express.
Episcopia B.-Vienna O. W.-Munich-Paris-Boulogne	Vict.	2 847+170	1 770 + 106	R 9.00 a. m.	56.25	56.7	35.2	Arlberg Express.
Episcopia B.-Vienna O. W.-Innsbruck-Paris E.-N.-Boulogne	Vict.	2 923+170	1 816 + 106	R 2.00 p. m.	51.25	60.2	37.4	Do.
Decebal-Vienna W.-Brussels N.-Ostend	Vict.	2 728+236	1 695 + 147	R 7.12 p. m.	46.12	64.9	40.3	Ostend-Vienna Express.
Decebal-Vienna W.-Munich-Châlons-Boulogne	Vict.	2 737 + 170	1 701 + 106	R 2.00 p. m.	46.15	62.9	29.1	Orient Express.
Gr. Ghica Voda-Lwow-Berlin-Brussels N.-Ostend	Vict.	2 554+236	1 587 + 147	R 3.00 p. m.	49.34	56.5	35.1	Nord Express.

rest and Sofia, either by the direct Giurgiu-Roussé route (489 km. = 304 miles) (for which the introduction of a ferry-boat service on the Danube is under consideration) nor by the longer roundabout all-rail route via Oborichté (899 km. = 558.6 miles), while to travel from Bucharest to Belgrade it is also necessary to make a wide circuit via Vinkovci (885 km. = 550 miles) (1).

Table 247 shows the comparative distances from Bucharest to the chief capitals of Central and Western Europe, with the actual distances.

When two different mileages are given, the first refers to the Continental, and the second to the mileages from the Continental port to London, which are as follows :

	Km.	Miles.
London Liv. St.-Harwich	111	69.0
Do. Vict.-Dover	125	77.7
Do. Vict.-Folkestone	118	73.3
Folkestone-Flushing	188	116.8
Harwich-Hook of Holland	103	64.0
Do. -Rotterdam	121	75.2
Folkestone-Boulogne	52	32.3
Dover-Ostend	111	69.0
Do. -Calais	42	26.1

XLI-6. — **The International Sleeping Car Company's trains** (fig. 260) all serve Bucharest which has been linked up with the western Capitals by a series of lines. Far apart to begin with, they afterwards cross and recross each other before joining up definitely to finish up. It is indeed astonishing to find that their length is such that they can, without being excessively circuitous, lie as far as 1 227 km. (762.5 miles) apart, this being the distance by rail from Berlin to Milan on both Bucharest-Paris through routes.

The oldest of these trains is the « Orient Express » which was also the Company's first « de luxe » train. Originally intended to link up Paris and Istanbul, it began running between Paris and Vienna, and as there was a wide gap in Bulgaria, it was diverted so as to run via Rumania with a boat connection to Constantinople. At first and for quite a time, the route was switched south from Bucharest to the Danubian port of Giurgiu (80 km. = 50 miles). A connecting Bulgarian train from the opposite shore ran over the *British Roussé-Varna Railway Company*'s 225 km. (140 miles) to Varna, where passengers embarked for the 310-km. (193 miles) crossing to Constantinople (2).

The total distance from Bucharest was 615 km. (382 miles) and from Paris Est, 3 174 km. (1 972 miles). This was the origin of the pre-war mixed rail and sea service, which was altered on completion of the through Bulgarian line. This brought Istanbul within 3 124 km. (1 943 miles) from Paris, as from 1894 a « de luxe » train ran direct to Sofia and Istanbul, while the mixed route in Rumania was then altered, the Bucharest train running on to the Rumanian port of Constanza, from which place there was a 359-km. (223 miles) crossing to Istanbul taking 12 hours, thus reaching Istanbul a bare half hour later than by the Bulgarian all-rail route.

After the Armistice, two other Eastern trains were introduced. First of all the « Simplon-Orient Express » formed at Milan of rakes coming from Lyons (and Bordeaux), Paris (and Calais) and Ostend, provided new services between Southern Europe and the Near East. The Rumanian part of this journey has not

(1) Best time from Belgrade 21 h. 50 m.
(2) Cf. *Les Chemins de fer de la Bulgarie* (Bulgarian Railways), by the same author.

Fig. 260. — *International Sleeping-Car Company* train services in Rumania.

We have added the runs of all *Rumanian State Railways* « rapides ». This map thus shows all fast Rumanian train services, whether *International Sleeping-Car Company* or *State Railways* « rapides ».

Legend :

Sleeping-Car Co. train.
Discontinued Sleeping-Car Co. trains.
Pullman-car trains.
Pullman and sleeping-car trains.
Other fast expresses.
Do. (discontinued).

changed since the train was introduced, but the rakes from Ostend and Lyons have been discontinued.

When the former « Orient Express » was reintroduced, its Rumanian route was altered so as to avoid crossing the Jugoslav frontier twice, and it was run over the Arad, instead of the Timisoara line. In addition, as Istanbul had lost some of its importance, it was superfluous to serve the Turkish capital via Rumania, and the Bucharest-Constanza-Istanbul section was soon discontinued.

Then came the « Arlberg-Orient Express » from Paris, which was successively extended to Vienna, to Budapest and

TABLE 248.

JOURNEY TIMES BETWEEN BUCHAREST AND PARIS.

INT. SLEEPING-CAR. CO. TRAIN.	Distance. In Rumania. Km.	Distance. In Rumania. Miles.	Distance. Total. Km.	Distance. Total. Miles.	Best time.
Berlin and the « Nord Express »	563	349.8	2 802	1 741.1	R 43.56
Orient Express	647	402.0	2 557	1 588.9	40.05
Arlberg-Orient Express .	660	410.1	2 457	1 526.7	R 45.10
Simplon-Orient Express .	614	381.5	2 978	1 850.5	R 48.15

finally to the Balkans. These three trains all run from Bucharest to Paris.

On, the other hand, Ostend and Brussels are linked up with Bucharest by the « Ostend-Vienna-Orient Express », which included for quite a time, a Calais-Brussels-Vienna rake, and now a through rake from Amsterdam, which joins the train at Cologne.

After the War, one of the rakes making up the « Simplon Orient » came from Ostend and ran to Milan via Strasbourg.

TABLE 249.

JOURNEY TIMES BETWEEN BUCHAREST AND OSTEND.

SLEEPING-CAR CO. SERVICE.	Distance. In Rumania. Km.	Distance. In Rumania. Miles.	Distance. Total. Km.	Distance. Total. Miles.	Best time.
Breslau and the « Nord Express »	563	349.8	2 535	1 575.2	R 43.03
Ostend-Vienna-Orient Express	647	402.0	2 280	1 416.7	R 38.43
Simplon-Orient Express and Milan	614	381.5	2 820	1 752.3	...

This having been done away with, and in order to provide a daily service from Ostend, in spite of the « Ostend-Vienna » only running three times a week, a new service to Bucharest was introduced on the 15th May 1934, making, use of the « Nord Express » as far as Berlin, from which place a through Ostend sleeping car runs on to Bucharest via Breslau.

Table 250*a*.

TRAINS OF THE INTERNATIONAL SLEEPING-CAR COMPANY SERVING THE WESTERN CAPITALS AND BUCHAREST.

(Discontinued trains shown *in italics*.)

TO BUCHAREST.				Time of departure.	Time spent.	Date and frontier station.
Origin.	Route followed.	Distance. Km.	Distance. Miles.			
	Orient-Express.					
Paris Est.	*Munich-Vienna W.-Timisoara* .	2 569	1 596.3	*7.08* p. m.	*51.22*	In 1902.
				7.13 p. m.	*45 25*	In 1913.
Calais Mar.	Paris-Vienna-Arad	2 877	1 787.7	*3.10* p. m.	*49.45*	In 1929.
Paris Est.	Laon-Vienna W.-Arad . . .	2 572	1 598 2	7.55 p. m.	40.20	In 1935.
Calais Mar.		2 781	1 728.1	5.25 p. m.	42 50	Do.
	Ostend-Vienna.					
Ostend Quay.	*Brussels N.-Cologne-Vienna-Timisoara*	(1) 2 714	1 686.4	*4.46* p. m.	*49.19*	In 1902.
Calais Mar.		(2) 2 719	1 689.5	*6.40* p. m.	*45.58*	In 1913.
		2 823	1 754.2	*12.47* p. m.	*53.18*	In 1902.
Ostend Quay.	Cologne-Vienna-Arad	2 713	1 685.8	*8.55* p. m.	*43.00*	In 1929.
				8.32 p. m.	38.43	In 1935.
Amsterdam C.S.		2 529	1 571.5	*8.11* p. m.	*43.44*	In 1929.
				8.42 p. m.	39.53	In 1935.
	Arlberg-Express.					
Calais Mar.	Chaumont-Buchs-Oradea Mare .	2 958	1 838.0	5.25 p. m.	42.50	In 1935.
Paris Est.		2 653	1 648.5	7.55 p. m.	40.20	Do.
	Simplon-Orient.					
Paris P.L.M.	Milan-Jimbolia	2 695	1 674.6	9.25 a. m.	48.15	In 1929.
Calais Mar.	Paris N.-P.L.M.-Milan-Jimbolia	3 009	1 869.7	2.30 p. m.	54.25	In 1935.

Table 250*b*.

TRAINS WORKED BY THE RAILWAY ADMINISTRATIONS.

Origin.	Route followed.	Km.	Miles.	Time of departure.	Time spent.	Date and frontier station.
Berlin Anh.	Prague Galanta-Budapest .	1 863	1 157.6	1.50 p. m.	39.30	Decebal.
Berlin Fr. Str.	Bohumin Galanta-Budapest .	1 841	1 144.0	...	...	No « rapide ».
Berlin Fr. Str.	Breslau-Lwow	1 757	1 091.8	9.20 a. m.	30.15	Gr. Ghica Voda.
Prague Mas.	Bratislava-Szob-Budapest . .	1 649	1 024.7	1.50 p. m.	27.35	Episcopia Bihor.
Prague Wils.	Bohumin-Krkov-Lwow . . .	1 650	1 025.3	9.20 a. m.	30.15	Gr. Ghica Voda
Warsaw.	Deblin-Lwow	1 305	810.9	R 9.40 a. m.	22.54	Do.
Sofia.	Giurgiu-Pleven	489	303.8	R 8.10 a. m.	13.05	Giurgiu.

(1) By the left bank of the Rhine.
(2) By the right bank of the Rhine.

Table 251.

RUMANIAN SECTIONS OF INTERNATIONAL SLEEPING-CAR COMPANY TRAIN RUNS.

(Obsolete trains shown *in italics*).

Route: Origin.	Route: Rumanian section.	Route: Destination.	Distance: Km.	Distance: Miles.	Time of departure.	Time spent.	Name of train.
	International trains.						
Paris Est.	*Timisoara-Bucharest N.-E.- Giurgiu . . . .*	*Varna, Istanbul.*	655	407.0	*6.24* a. m.	*16.21*	*Orient Express* (1883).
Paris Est. and Ostend Quay.	*Szeged - Timisoara - Bucharest N.-Constanza . . . . .*	*Istanbul.*	802	498.3	*4.40* a. m.	*18.50*	*Orient Express and* Ostend-Vienna. (pre-war).
Calais, Paris. and Ostend Quay.	*Curtici (Decebal) - Bucharest N.-Constanza . . . . . .*	...	874	543.1	*6.24* a. m.	*16.21*	*Orient Express* (1924).
Paris Est. Calais Mar. and Ostend Quay.	Decebal-Bucharest Nord . . .	...	647	402.0	3.03 a. m.	10.12	Orient Express Ostend-Vienna.
Calais, Paris.	Jimbolia-Bucharest Nord . .	...	614	381.5	11.39 a. m.	10.16	Simplon-Orient Express.
Calais Mar. and Paris Est.	Episcopia Bihor.-Bucharest N.	...	660	410.1	6.10 a. m.	12.25	Arlberg-Orient Express.
	Internal trains.						
...	*Bucharest Nord-Brasov . . .*	...	170	105.6	*5.40* p. m.	*3.27*	*Carpati Pullman Express.*
...	Bucharest Nord-Galati . . .	...	260	161.6	7.00 p. m.	3.45	Danubiu Pullman.
...	Bucharest Nord-Constanza (Ville)	...	227	141.1	6.40 p. m.	3.13	Rap. Regele Carol I.
...	Bucharest Nord-Constanza-Port (1)	...	227	141.1	Do.	3 55	Do.
...	Bucharest Nord-Constanza V. Carmen Sylva	...	249	154.7	Do.	4.10	Do.

This completes the fleet of trains to date.

Three Pullman trains run in Rumania :

The « Danubiu Pullman Express » connects Bucharest with Galati. The « Fulger Regele Carol I » runs between Bucharest and Constanza, and is extended, during the season, to Carmen Sylva, a seaside resort, and to Constanza Harbour Station, the days when the Rumanian steam packets ply.

The « Carpati Express », a Summer train, was introduced on the 15th May

(1) Is run on the days the S. M. R. boats ply.

Fig. 261. — Map showing the services of the *International Sleeping-Car Company* trains, linking up Bucharest with Central and Western Europe.

Legend :

« De luxe » trains.
Do. (obsolete).
Isolated Sleeping-Car Co. vehicles.
Other « de luxe » trains.

1929, but is no longer a Pullman train. It serves Sinaïa, a well known health resort (125th km. = 77.7th mile). When the train exceeds five coaches, double heading is required on the difficult Ploesti Vest-Campina section.

XIII. — CZECHOSLOVAKIA.

SUMMARY.

CHAPTER XLII.

CHAPTER XLII.

XLII-1. — **General.** — The orientation of the Czechoslovak railway system has completely changed since the War so as to endeavour to endow it with the characteristics which it lacked. Lines radiating from the Capital had to be maintained or built; some of the traffic currents of the former Austrian Empire have persisted and the importance of some of the others has greatly increased, or the reverse. It follows that the transverse lines of the system play an uncommon part, and when the elongated shape of the country is remembered, the whole situation appears quite unusual.

HEALTH RESORTS. — Cheb (Eger) is a secondary international centre where routes from Paris, Ostend, Berlin and Vienna converge, before serving the watering places of Karlovy Vary (Carlsbad) and Marianské Lazné (Marienbad).

GALICIA is a long strip of which there are only four examples in Europe, and as in the other three cases, is served by a single long central railway line (see table hereafter).

(The length of the railway lines is shown *in italics*).

STRIP.	Length. Km.	Length. Miles.	Farthest place at both ends.	Width. Km.	Width. Miles.
Thessaly (Greece)	300 *555*	186.4 *344.9*	Pithion-Solun.	30 to 60. *96* (1).	18.6 to 37.3. *59.6* (1).
Tyrol (Austria)	290 *393*	180.2 *244.2*	Feldkirch-Schwarzach.	40 to 55. *72 and 47* (2).	24.9 to 34.2. *44.7 and 29.2* (2).
Silesia (Germany) . . .	... *245*	... *152.2*	Liegnitz-Beuthen.	... *138* (3).	... *85.7* (3).
Galicia (Czechoslovakia) .	290 *420*	180.2 *261.0*	Strba-Trebusany.	Max. 80. ...	Max. 49.7. ...
...	850 *1229*	528.2 *763.7*	Eger-Trebusany.	Max. 240. *356* (4).	Max. 149.1. *221.2* (4).

(1) Solun Skindra line.
(2) Brennero-Innsbruck-Scharmitz and Lindau-Bregenz-Feldkirch lines.
(3) Dittesberg-Breslau-Oels-Wartenberg lines.
(4) Horni-Dvotiste-Prague-Podmokly line.

This special situation is due to the longitudinal division of the country between Czechoslovakia and Poland, the line North of the Carpathians having been transferred to the former, and the Trans-Carpathian to the latter. Both routes are used by the international trains between Berlin and Bucharest, the distances being as follows :

Berlin Schl.	-Breslau-Bohumin-Halmei-Bucharest N.	1 893 km.	(1 176.3 miles).
Do.	-Prague-Karlovo-Oradea Mare-Bucharest N. . . .	2 113 km.	(1 313.0 miles).
Do.	-Prague-Galanta-Budapest-Oradea-Bucharest N. . .	1 883 km.	(1 170.1 miles).
Do.	-Beuthen-*Poland*-Gr. Ghica-Bucharest	1 757 km.	(1 091.8 miles).

In Czechoslovakia, the Galician line, relatively to the southern frontier of the country, has the peculiar characteristics we have mentioned previously ([1]) (fig. 257). At suitable distances, some half dozen branches running South and North each of them about 100 km. (62 miles) long, link up the southern frontier and the long East-West line with the country's northern frontier :

JUNCTION STATION.	Distance from Bohumin.		Czechoslovak branch.			Towards
	Km.	Miles.	As far as	Km.	Miles.	
Zilina	103	64.0				
Kralovany	143	88.9	Sucha Hora . . .	71	44.1	Nowy Targ.
Kysac Obysovce . .	337	209.1	Orlov Plavec . . .	91	56.5	Tarnow, Krakow.
Legina Michalany .	402	249.8	Medzilaborce . . .	126	78.3	Przemysl.
Cop	460	285.8	Uzoc	121	75.2	Lwow.
Bafovo	475	295.2	Skotarsky	108	67.1	Stryj.
Trebusany	643	399 5	Jasina	68	42.3	Stanislawow.

The western part of this same railway has also special frontier characteristics. The important railway centre, Bohumin (Oderberg) lying in Czechoslovakia, the Berlin-Breslau-Lwow-Bucharest main line takes a sudden turn down to Bohumin in Czechoslovakia exactly opposite the German-Polish frontier. Further on, the opposite occurs, as the same railway makes a loop into Germany in order to serve the German town of Ziegenhals (fig. 262).

([1]) It actually runs along the frontier from Kosice (353rd km. = 219th mile from Zilina) and even crosses the frontier into Rumanian territory between Teresva (596th km. = 370th mile) and Dragos Voda (600th km. = 373rd mile) returning to Czechoslovakia between Valea Visaului (639th km. = 397th mile) and Trebusany (643rd km. = 400th mile) whence it makes a sudden turn towards the northern frontier of the country, which is close by.

XLII-2. — **The railway system.** — MOST RAILWAY COMPANIES have been bought up since the Republic was founded. Out of a total of 13 519 km. (8 400

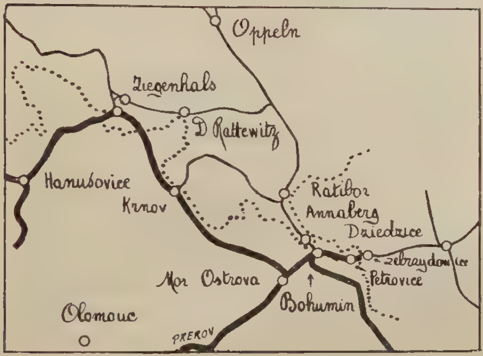


Fig. 262.

miles) of railway, the *State* operates 13 237 km. (8 225 miles), (11 199 km. = 6 959 miles of which are actually owned by it, and 2 038 km. = 1 266 miles operated on behalf of private companies). Only 266 km. (165 miles) are still under private ownership; there are also some 16 km. (10 miles) of railway in foreign territory.

The *Deutsche Reichsbahn* runs into Czechoslovakia in two places. The German line from Breslau continues from Annaberg as far as Bohumin (5 km. = 3.1 miles) (fig. 262).

On the other hand, all the lines to Cheb, and those from the North and West also belong to the *Reichsbahn* (fig. 263). The most interesting is obviously the line from Cheb (Eger) to Plauen where the 15 km. (9.3 miles) from Cheb to the frontier station of Voitersreuth serve, at the 6th km. (3.7th mile), the

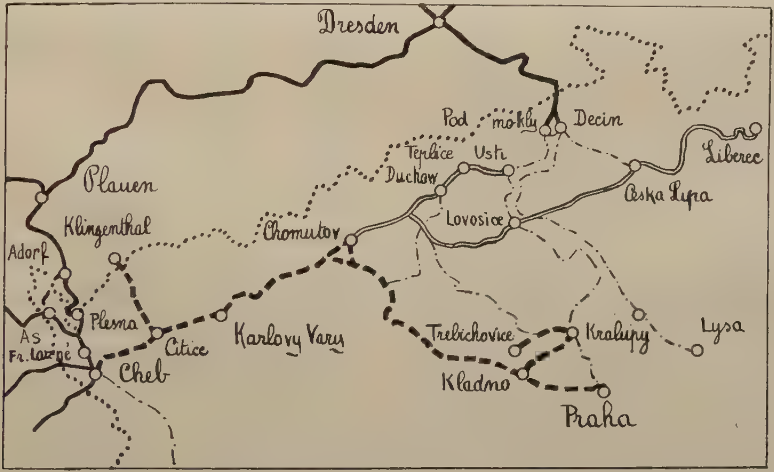


Fig. 263. — **Railway lines in the North of Czechoslovakia.**

Heavy full line = *Deutsche Reichsbahn*. — Heavy bar line = Former *Buchterader Eisenbahn*. — Two thin paralel lines = Former *Aussig-Töplitz* Railway. — Dot-and-dash = Former *State Railway* system.

watering place of Frantiskovy Lazné (Franzenbad). It is a curious fact that two of these *Reichsbahn* lines are joined up between As and Adorf by a Czechoslovakian line 29 km. (18 miles) long, only the first 16 km. (10 miles) of which lie in Czechoslovakia and the balance in Germany (1).

(1) Frontier station : Rossbach.

The existence of certain pre-war companies had a direct effect upon the present constitution of the railway system, owing to the juxtaposition of certain lines or the survival of certain particular economic conditions.

The former *Buchterader Eisenbahn* [1] (fig. 263) had a mileage of 330 km. (205 miles) and served the Bohemian spas; the *Aussig-Töplitz* Railway (247 km. = 153.5 miles) linked up Prague and the German frontier [2] which explains the co-existence of two main lines between Prague and Decin (136 km. = 84.5 miles) and between Prague and Podmokly (130 km. = 80.8 miles). Finally the *Kaschau-Oderberg* Railway, which crosses the Carpathians [3] at the beginning of the long Galician line which the *Czechoslovak State Railways* have incorporated into their system.

Although Czechoslovakia has mountainous frontiers, the railways of former Bohemia are not hilly, and do not ascend to any great height. The line from Plzen (321 m. = 1 053 feet above sea level) to Cheb (424 m. = 1 391 feet) reaches its highest point at Lozne which is only 602 m. (1 975 feet) above sea level.

The Galician main line crosses two successive ranges :

	Distance.		Altitude.	
	Km.	Miles.	Metres.	Feet.
Bohumin	...	...	+ 199	653
Before Mosty	60	37.3	519	1 702
Vrutky	122	75.8	385	1 263
Strba	221	137.3	890	2 920
Kosice	351	218.1	205	672
Kralovo	542	336.8	123	408
Zimir	692	430.0	729	239
Woronienka	701	435.6	887	291

The line from West to East through the middle of Slovakia is still incomplete, but several of its sections are in operation. It crosses the White Carpathians between Veseli, on the Morava, and Nove Mesto on the Van (68th km. = 42nd mile) by a tunnel 2.5 km. (1.55 miles) long linking up Moravia and Slovakia

(1) This system was made up as follows :

Eger-Carlsbad-Kordau-Luzna-Prague	241 km.	(149.7 miles).
Kladno-Gralup-Welvarn	38 km.	(23.6 miles).
Do. -Strebichowitz branch	21 km.	(13.0 miles).
Klingenthal-Falkenau	30 km.	(18.6 miles).

(2) This system included the lines hereafter :

Aussig-Töplitz-Dux-Komotau (towards Carlsbad)	66 km.	(41 miles).
Aussig-Bilin	32 km.	(20 miles).
Töplitz-Lobovitz-Bohm-Leipa-Reichenberg	149 km.	(92.6 miles).

(3) The main line runs from Kaschau (Kosice), 273 km. = 169.6 miles from Budapest, via Ruttek (230th km. = 143rd mile) and Silein Szolna (250th km. = 155th mile), to Oderberg (351st km. = 218th mile). There was also a branch line 87 km. (54 miles) long as far as Orlo, in the direction of Tarnow.

and the hilly section 19 km. (11.8 miles) long from Handlova-Hornia to Stubna by a series of tunnels, the longest of which is 3 km. (1.86 miles).

XLII-3. — **International transverse lines** — There are a series of lines of this kind, all running from North to South :

TABLE 252.
INTERNATIONAL TRANSVERSE LINES.

WHOLE ROUTE.		CZECHOSLOVAK SECTION.			
from	to	from	to	Distance. Km.	Distance. Miles.
Berlin A. . .	Trieste or Vienna.	Podmokly . . .	Prague-Breclav.	416	258.5
Berlin A. . .	Budapest-Orient.	Do. . . .	Prague-Szob.	677	420.7
Warsaw . .	Vienna F. J.	Zebrzydowice . .	Petrovice-Breclav.	208	129.3
Berlin Schl. .	Budapest-Orient.	Bohumin	Zilina-Galanta-Szob.	373	231.8

Owing to political and economical contingencies, the Prague-Bohumin-Warsaw services (1) (785 km. = 487.8 miles) are now far more important than they used to be.

XLII-4. — **Services through Prague.** — As the Czechoslovak system was made up, for the most part, of a series of independent railways, several of which had their own terminus in Prague, the railway situation in the capital is complicated and inadequate and is about to be reorganised. In order to connect some of the termini, do away with others, and improve through services, this was started during the war, and a connection between the Warsaw station in the South and the Liben Station, in the East, linking up the old *Warsaw-Vienna Railway* with the eastern lines, was built. Since then, the Vienna line having lost its importance, the Viennese N. W. terminus has been closed down.

At Prague the Wilson (formerly Franz-Josef) station will become the chief station, and the Denis and Masaryk stations will be closed down.

XLII-5. — **Train services.** — The Czechoslovak Railways make a distinction between R trains « rapides » L trains « de luxe » S trains (accelerated), O trains (omnibus = local trains) and N trains (mixed goods and passenger trains). When the services are worked by rail motor coach, the trains are classified under MR, MS and MO.

Trains are often rather heavy. The Podmokly-Prague-Szob trains (express trains 147-148) made up of nine bogie coaches weigh 450 t. (442.8 Engl. tons) with 86-t. (84.6 Engl. tons) locomotives, or 144 t. (141.7 Engl. tons) with tender. As it has been strengthened, the line can carry locomotives weighing 89.6 t. (88.2 Engl. tons) [155 t. = 152.5 Engl. tons with tender], with an axle load of 16.9 t. instead of 14.7 t. (16.6 Engl. t. instead of 14.4), i.e. 50 t. (49.2 Engl. tons) adhesive weight instead of 44 (44.3 Engl. t.). This makes it possible to in-

(1) Via Katowice the distance from the frontier (Zebrzydowice) to Warsaw is 398 km. (247.3 miles). Via Trzebinia, 463 km. (287.7 miles).

crease the weight of the trains to 500 t. (492 Engl. tons).

The speed of the trains of perishables is 60 km. (37.3 miles) and even 70 km. (43.5 miles) an hour.

Through goods trains, carrying high-rated goods, are booked to run at 50 to 60 km. (31 to 37.3 miles) an hour.

XLII-6. — **Railcars.** — Czechoslovakia is one of the countries where the greatest use of railcars is made, first on secondary lines, later, on main lines for fast services carrying few passengers. The latter are worked with triplet sets, the first of which, operated in 1933 between Prague and Bratislava, was named the « Blue Arrow ». This was followed by similar rakes used for services radiating from Prague to Liberec, Teplice and Budejovice, and also between Prerov and Bratislava.

These vehicles, built by the *Ringhofferovy Zavody Company*, of Smichov, have a 380-H.P. Hesselman diesel engine; they seat 64 passengers in the motor unit and 81 in each of the two trailers. They weigh 23.7 t. (23.3 Engl. tons). Their speed varies from 20 to 120 km. (12.4 to 75 miles) an hour.

XLII-7. — **Czechoslovak train speeds.** — Noteworthy train runs are shown in tables 253 and 254, and the maximum overall speeds of the various express services of the system are shown in the cartogram figure 264.

Out of the entire standard gauge system :

1 377 km. (855.6 miles) i.e. 10.2 % is run over at overall speeds between 70 and 79.9 km. (43.4 and 49.9 miles) an hour;

2 430 km. (1 510 miles) i.e. 18 % at overall speeds between 60 and 69.9 km. (37.4 and 43.4 miles) an hour;

9 712 km. (6 035 miles) i.e. 71.8 % at overall speeds below 60 km. (37.4 miles) an hour.

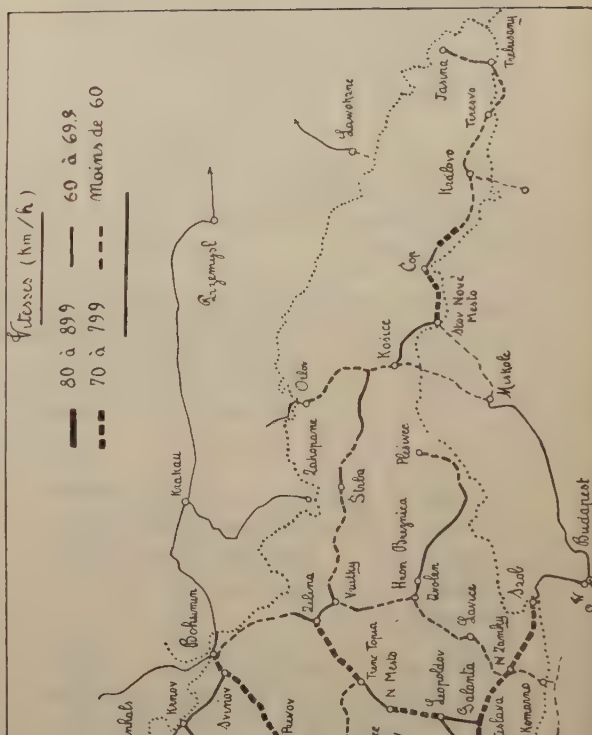


Fig. 264. — Cartogram showing the maximum overall speeds on the *Czechoslovak Railways.*

Table 253.

NOTEWORTHY CZECHOSLOVAK RUNS.

Non-stop runs are shown in **heavy** type.

ROUTE.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Speed. Km./h.	Speed. Miles/h.	Number of stops.	—
rague M.-Kolin - Ceska Trebova - Brno-Szob	548	340.5	1.48 p. m.	8.14	66.6	41.4	6	Rap. Budapest-Istanbul.
Prague M.-Cesky Brod-Kolin	63	39.1	2.41 p. m.	0.55	68.7	42.7	...	Do.
Do. -Chocen	139	86.4	1.48 p. m.	1.51	75.1	46.7	...	Do.
Do. -Ceska Trebova	164	101.9	R 2.50 p. m.	2.10	75.7	47.0	...	
Do. -Pardubice	105	65.2	8.43 p. m.	1.30	63.0	39.1	...	
Breclav-Bratislava	81	50.3	6.40 p. m.	1.05	75.0	46.6	...	
Ceska Trebova-Brno	91	56.5	11.23 p. m.	1.27	62 8	39.0	...	
Bratislava-Galanta-Nove Zamby	92	57.2	3.17 a. m.	1.15	73.6	45.7	...	
(Vienna) Bratislava-Szob	151	93.8	7.34 p. m.	2.01	74.8	46.5	...	Orient Exp. (R.) Bucharest.
rague W.-Tabor-České Velenice	186	115.6	4.15 p. m.	3.00	62.0	38.5	3	Rap. Berlin-Vienna.
Mezimosti-České Velenice	54	33.5	6.29 p. m.	0.46	70.4	43.7	...	
Prague W.-Benesov	52	32.3	R 12.38 p. m.	0.44	70.9	44.1	...	
rague W.-Tabor-Horni-Dvoriste	226	140.4	10.35 p. m.	4.35	49.5	30.8	7	Rap. Linz-Trieste.
rague W.-Plzen-Cheb (Eger)	222	138.0	4.06 p. m.	3.22	65.4	40.6	2	Rap. Paris-Prague.
Prague W.-Plzen	115	71.5	Do.	1.41	61.4	38.2	...	Do.
Plzen-Marianské Lazné	76	47.2	5.53 p. m.	1.08	67.1	41.7	...	Do.
Marianské Lazné-Cheb	31	19.3	7.02 p. m.	0.26	71.5	44.4	...	Do.
zen-Ceské Velenice	186	115.6	2.00 p. m.	2.50	65.6	40.8	...	Transverse run to Vienna .
Plzen-Ceské Budejovice	136	84.5	6.58 p. m.	2.01	67.4	41.9	3	M.S. (railcar).
Plzen-Horazdovic Babin	60	37.3	Do.	0.52	70.0	43.5	...	M.S. (Do.)
zen-Zatec-Duchcov	152	94.4	6.20 a. m.	3.03	49.9	31.0	10	M.S. (Do.)
rague W.-Krupa-Chumatov-K. Vary-Cheb	242	150.4	R 9.00 a. m.	4.25	47.8	29.7	9	Rap. from Berlin Anh.
Prague W.-Karlovy Vary	190	118.1	8.10 a. m.	3.27	55.1	34.2	2	Rap. from Bucharest.
(Prague) Devnice-Zatec Mesto	100	62.1	8.23 a. m.	1.47	56.1	34.9	...	Do.
Zatec Mesto-Ostrov	68	42.3	R 1.31 a. m.	1.00	68.0	42.3	...	Do.
K. Vary-Trsnice	46	28.6	2.47 p. m.	0.44	62.7	39.0	...	Rapide.
Do. -Cheb	52	32.3	R 12.19 p. m.	0.51	61.2	38.0	...	« Luxe » Paris-Ostend.
Prague M.-Zatec Mesto	106	65.9	R 6.35 p. m.	1.59	53.5	33.2	...	Rap. Bucharest.
rague M.-Podmokly	130	80.8	5.14 p. m.	1.44	75.0	46.6	...	Rap. Athens, Vienna and Berlin.
rague W.-Melnik Détin	136	84.5	R 3.40 a. m.	2.17	58.8	36.5	3	Rap. Vienna-Berlin.
rague W.-Lysa-Hanusovice (Bohumin)	230	142.9	R 10.46 a. m.	4.06	56.1	34.9	8	Rap. Breslau.
Velky-Osek-Hradec-Kralové	51	31.7	R 6.16 a. m.	0.43	71.2	44.2	...	
rague W.-C. Trebova-Bohumin	366	227.4	9.08 p. m.	5.20	68.6	42.6	5	Rap. Jasina Bucharest.
C. Trebova-Olomouc	86	53.4	11.33 p. m.	1.08	75.9	47.2	...	Do.
Olomouc-Prérov	24	14.9	12.43 a. m.	0.18	80.0	49.7	...	Do.
Prérov-Mor. Ostrava	84	52.2	1.07 a. m.	1.09	73.0	45.4	...	Do.
reclav-Prérov	101	62.8	1.25 a. m.	1.30	67.9	42.2	1	Rap. Rome, Berlin and Warsaw.
Bréclav-Otokovice	72	44.7	Do.	1.03	68.6	42.6	...	
ratislava-Zilina-Kosice	453	281.5	9.35 a. m.	8.11	55.5	34.5	18	Rap. Istanbul.
Trenc-Zilina	71	44.1	R 1.10 p. m.	0.58	75.1	46.7	...	Vienna (Berlin).
rague W.) Bohumin-Zilina-Zloven-Plesivei	368	228.7	5.20 a. m.	7.32	48.6	30.2	23	Rap. Budapest.
hhumin-Kosice-Kralovo	544	338.0	2.38 a. m.	10.04	54.4	33.8	19	Rap. Bucharest.
erlin) Bohumin-Kosice	353	219.4	3.22 p. m.	6.54	50.1	31.1	12	Rap. Istanbul.
Slov-Nové Mesto-Cop	42	26.1	10.38 a. m.	0.35	72.0	44.7	...	Rap. Bucharest.

XLII-8. — **Two series of International Sleeping-Car Company trains** serve Czechoslovakia : those running to watering places, and these to the Near East, or, if preferred, trains finishing in Czechoslovakia and through trains.

The former, from Paris, Ostend, and Berlin, serve Karlovy Vary (Carlsbad), Marianske Lazné (Marienbad) with an extension to Prague. To do this they usually divide at Eger (Cheb), from which place each of the trains runs independently for the very small remaining part of the journey.

The pre-war « Paris-Carlsbad » train included a Karlsruhe-Francfort rake. At the present time, the Karlovy-Vary section has been extended to Prague (Wilson).

The « Ostend-Carlsbad » was in actual fact just a rake of the « Ostend-Vienna » which was added to the « Paris-Prague » at Nurenberg, where the two routes crossed. For a short time, this train carried a through « Ostend-Wurzburg-Bad Kissingen » service.

The « Berlin Carlsbad » was for some time extended to Marienbad (where it was joined by an additional rake from

TABLE 254.

FASTEST AND LONGEST CZECHOSLOVAK NON-STOP RUNS.

RUN.	Length.		Time of departure.	Time spent.	Speed.		—
	Km.	Miles.			Km./h.	Miles/h.	
FASTEST TRAINS.							
Steam traction.							
(Prague W.) Olomouc-Prerov . .	24	14.9	12.43 a. m.	0.18	80.0	49.7	Rap. Jasina Bucharest.
Do. -C. Trebova-Olomouc.	86	53.4	11.33 p. m.	1.08	75.9	47.2	Do.
(Prague M.)-Ceska Trebova . .	164	101.9	R 2.50 p. m.	2.10	75.7	47.1	Rap. Bucharest.
Prague M.-Chocen	139	86.4	1.48 p. m.	1.51	75.1	46.7	Do.
Ceska Trebova-Brno	81	50.3	6.40 p. m.	1.05	75.0	46.6	
Prague M.-Podmokly	130	80.8	5.14 p. m.	1.44	75.0	46.6	Rap. Berlin-Vienna.
Trenc-Zilina	71	44.1	R 1.10 p. m.	0.58	75.1	46.7	Rap. Berlin-Budapest.
Railcars.							
(Plzen) Horazdovic-Strakonice .	17	10.6	7.51 p. m.	0.14	72.8	45.2	
Plzen-Horazdovic Babin	60	37.3	6.58 p. m.	0 52	70.0	43.5	
(Plzen) Strakonice-Protivin . .	23	14.3	8.06 p. m.	0.19	72.6	45.1	
LONGEST NON-STOP RUNS.							
Steam traction.							
(Vienna) Bratislava-Szob . . .	151	93.8	7.34 p. m.	2.01	74.8	46.5	Orient Express.
Prague M.-Ceska Trebova . . .	164	101.9	R 2.50 p. m.	2.10	75.7	47.0	Rap. Budapest.
Prague-Chocen	139	86.4	1.48 p. m.	1.51	75.1	46.7	Do.
Prague M.-Podmokly	130	80.8	5.14 p. m.	1.44	75.0	46.6	Rap. Berlin-Vienna.
Prague W.-Plzen (Cheb) . . .	115	71.5	4.06 p. m.	1.41	61.4	38.2	Rap. Paris.
Prague M.-Zatec Mesto	106	65.9	R 6.35 p. m.	1.59	53.5	33.2	Rap. Bucharest.
Railcars.							
Plzen-Horazdovic Babin	60	37.3	6.58 p. m.	0.52	70.0	43.5	M.S.

TABLE 255.

INTERNATIONAL SLEEPING-CAR Co. SERVICES IN CZECHOSLOVAKIA.

(Obsolete services are shown *in italics.*)

Origin.	Czechoslovak section.	Destination.	Distance. Km.	Distance. Miles.	Time of departure.	Time spent.	Name of train.
	Transiting trains.						
and Ostend. Paris Est	Bratislava-Szob	Istanbul. Athens. Bucharest. *Constanta.*	151	93.8	6.26 p. m.	2.01	Orient Express. Ostend-Vienna Exp.
Paris-E.-Linz-Vienna.	*Breclav-Bohumin*	*Warsaw.*	*215*	*133.6*	*3.03* p. m.	*3.49*	*Orient Express.* (1920).
Paris Est and Ostend.	*Cheb-Prague-C. Trebova-Bohumin*	*Warsaw.*	*610*	*379.0*	*4.15* p. m	*12.26*	*Paris-Prague. Warsaw* (1921).
Berlin Schl.	*Cheb-Plzen-Gmund*	*Vienna F.J.*	308	191.4	*2.26* p. m.	*4.36*	*Berlin-Vienna Express* (1906).
Berlin Schl.	*Bohumin - Galanta (Parkany) Szob*	*Istanbul.*	373	231.8	*2.48* a. m.	*7.02*	*Berlin-Budapest Orient Express.*
St. Petersburg.	*Pietrowice - Bohumin - Prerov Lundenburg*	*Vienna-Cannes.*	215	133.6	3.11 a. m.	3.39	*St. Petersburg* (Vienna-Nice-Cannes Exp.).
	To watering places.						
alais and Paris Est.	Cheb-Prague-Wels	...	222	137.9	2.18 p. m.	1.41	Paris-Prague. Karlovy Vary.
	Cheb-Karlovy Vary	...	52	32.3	12.19 p. m.	0.51	Do.
Ostend.	Do.	...	52	32.3	Do.	Do.	Ostend-Karlovy Vary.
	Eger (Cheb)-Marienbad	...	31	19.3	*11.28* a. m.	*0.34*	*Ostend-Karlovy Vary-Marienbad.*
Berlin Schl.	*Vojtanov - Cheb - Karlsbad (Kar. V.)*	...	67	41.6	*2.47* p. m.	*1.04*	*Berlin-Vienna Express* (1906).
...	*Karlovy Vary-Mar.-Ceské Velenice*	*Vienna F.J.*	293	182.1	*1.20* p. m.	5.42	
Berlin Anhalt.	*Vojtanov - Cheb - Karlsbad (Kar. V.)*	...	67	41 6	*5.09* p. m.	*0.54*	*Berlin-Karlsbad.*
	Vojtanov-Eger (Cheb) Marienbad	...	46	28.6	*5.22* p. m.	*0.40*	*Berlin-Marienbad.*
	Prague services.						
aris Est (1)*-Linz.*	*Summerau-Tabor-Prague*	...	226	140.4	*7.47* a. m.	*5.08*	*Orient Express.* (1920).
alais and Paris Est.	Cheb-Prague W.	...	222	137.9	2.18 p. m.	1.41	Paris-Prague.

(1) Via Delle-Délémont-Basle and Innsbruck.

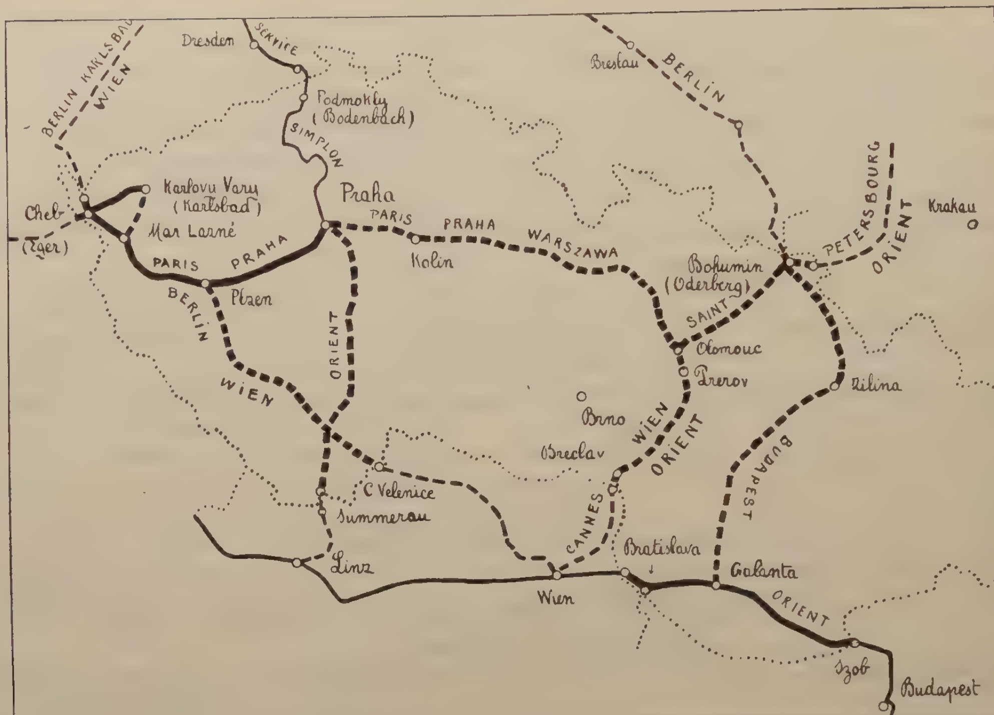


Fig. 265. — International Sleeping-Car Co. trains in Czechoslovakia.

Carlsbad), and thence right on to Vienna (1).

The Paris, Ostend, and Berlin-Near East trains run through without serving any particularly important places.

Between Vienna and Budapest, the « Orient Express » and the « Ostend-Vienna-Orient Express » run solid and non-stop between Bratislava and Szob (231 km. = 143.5 miles).

The « Berlin-Budapest Orient Express » of former times, joined up with them at Galanta, after having crossed the country from Oderberg (Bohumin) in the North.

Through services, in connection with the « Simplon-Orient Express » now link up Berlin with Galanta and Budapest, alternately by the old route via Bohumin and by the Dresden-Podmokly-Prague one respectively 958 and 982 km. (595.2 and 610.2 miles) long, 571 and 701 km. (354.8 and 435.6 miles) of which are in Czechoslovokia.

Finally when after the Armistice it became necessary to link up Paris with the Allied Capitals, certain trains were sent via Czechoslovakia to avoid running them through Germany.

(1) Distances between Berlin and Vienna :

Via Plauen-Mr. Lazné-Plsen-C. Velenice to Vienna F.J. .	827 km.	(513.9 miles).
Via Prague W.-Ceské Velenice to Vienna F.J.	722 km.	(448.6 miles).
Via Prague-Breclav to Vienna	753 km.	(467.9 miles).

(To be continued.)

[621.134.1 (.73) & 621. 135.2).73)]

Roller bearing rods on Pennsylvania Pacific type locomotive pass test service.

(Railway Age.)

A complete installation of roller-bearing rods, designed by The Timken Roller Bearing Company, was placed in service on Pennsylvania Railroad locomotive No. 5371, a K-4-S *Pacific* type, on July 4, 1934. Since that time the locomotive has made 96 000 miles in regular passenger service, during which no trouble has been experienced with the crosshead or crank-pin bearings. The locomotive has been operating in regular passenger service between Pittsburgh, Pa., and Columbus, Ohio.

The bearing installation required a complete redesign of rods and crank pins which also included the crosshead, piston rod and piston head. High-tensile alloy steel as employed in the new design effected a material reduction in weight of the reciprocating parts and weights on the crank pin. At the same time this new design provides the close bearing tolerances required for successful roller-bearing performance combined with the flexibility of rod alignment necessary in locomotive service.

The table shows a comparison of the weights on the crank pins and the weights of reciprocating parts of the locomotive with its original rods and after it was equipped with Timken roller-bearing rods. It will be seen that, with the Timken rods, there is a total reduction of weights on all three crank pins of 88 lb., which includes a net reduction of 40 lb. in the weights of the crank pins themselves, a reduction in weight on the main crank pin of 240 lb.,

Rod and bearing weights of Pennsylvania locomotive No. 5371.

Weights on the crank pins, lb.

With roller-bearing rods.

	Front.	Main.	Rear.	Total all drivers.
Weights fixed on pin	103	330	199	632
Weights revolving on pin	93	255	93	441
Rods	125	610	125	860
Total	321	1 195	417	1 933

With plain-bearing rods.

	Front.	Main.	Rear.	Total all drivers.
Crank pins and parts (fixed)	97	282	97	476
Weight on pins (revolving)	188	1 153	204	1 545
Total	285	1 435	301	2 021

Reciprocating parts.

	Timken. design.	Plain. bearings.	Saving over P. B. R.
Total weight crosshead and parts	387	599	212
Piston and details	364	484	120
Main rod, front half	226	402	176
Total	977	1 485	508

Fig. 1. — The Locomotive on which the roller-bearing-rod installation has made 96 000 miles in passenger service.

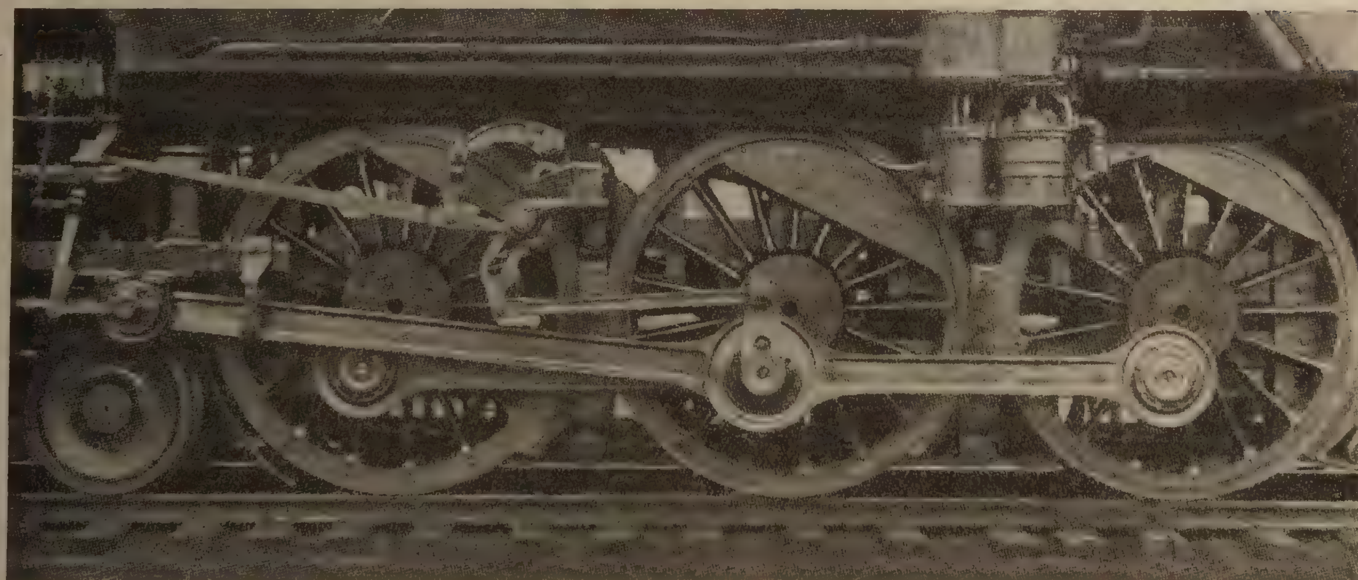


Fig. 2. — A closer view of the running gear.

and a reduction in the weight of the reciprocating parts of 508 lb. At 100 m.p.h. this effects a reduction in total crank-pin load of approximately 48 500 lb. With an overbalance of 170 lb. in each driving wheel, as compared with the 286 lb. originally in each wheel, the Timken-equipped locomotive may be run up to 117 m.p.h. before its dynamic augment reaches the value of that of the locomotive with the plain bearing rods at 90 m.p.h.

The outstanding features of the new design are : (1) The mounting of the roller bearings on the crank pins; (2) fitting of the rods to the bearings; (3) complete separation of the front and back sections of the side rods; (4) application of the main rod on the outer race of the main-pin bearing between the ends of the two side rods; (5) use of a crosshead having shoes pivoted around the crosshead pin, thus relieving the piston rod of eccentric loading from the guides. The piston, piston rod, the piston-rod key, crosshead forging, crosshead pin, main rod, side rods and crank pins are all of Timken High Dynamic steel, a chrome-nickel-molybdenum alloy heat treated to produce a yield point of 120 000 lb. and possessing high shock resisting qualities.

The bearings.

All bearings are fitted on the crank pins and not in the rods. On the main crank pin the bearing consists of two sets of rollers, each fitted in a separate cone. A portion of the inner cone and pin is tapered, ending in a 6 3/4-in. cylindrical fit toward the outer end of the cone. The cone at the outer end of the pin has cylindrical fit on the pin 6 in. in diameter. Around the pin taper between the two fits is a spacer between the bearing cones. Both sets of rollers are enclosed by a single cup or outer race.

The eyes of the rods, which are specially forged I-sections, bear directly on the cup, which is 13 1/2 in. in outside diameter. The rod bushings are of unusual design, each consisting of a 1/8-in. strip of hard rolled phosphor bronze, bent to shape, brazed, and pressed into the eye of the rod. A considerable reduction in rod weight is thus effected. The bores of the bushings are finished with a slight crown to provide the necessary freedom of angular movement of the rods on the bearing.

The front side rod is placed on the main pin bearing next to the wheel. Between this and the main rod is a light cylindrical spacer 3 15/16 in. wide. The back side rod is placed next to the main rod at the outer end of the bearing. A normal clearance of 1/32 in. is provided between each pair of adjoining surfaces for lateral movement of the rods on the pin. This is somewhat increased on the side of the pin opposite

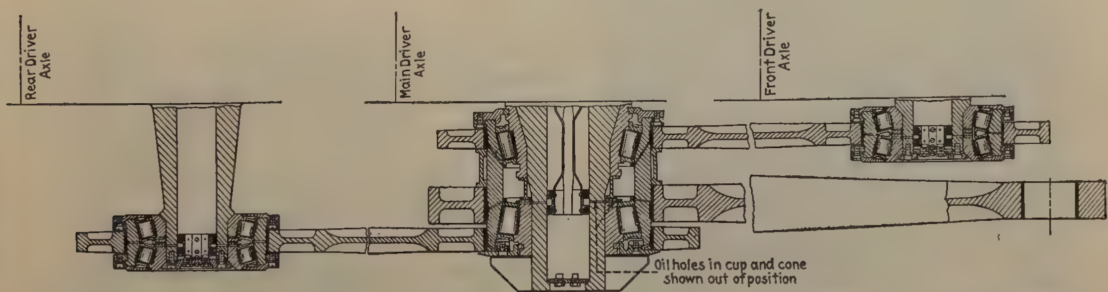


Fig. 3. — General arrangement of the Timken roller-bearing-rod installations on a Pennsulvania Pacific type locomotive.

the body of each rod by a slight taper in the width of the rod end to prevent cramping under augular movement of the rods with respect to their normal alignment at right angles to the center line of the crank pin. The overall length of the bearing cup is 10 11/16 in. Side-rod bearings are each 1 1/2 in. in length and the main-rod bearing 3 in. long.

The bearings on the front and back crank pins are made up of two sets of tapered rollers running in separate cones which are pressed on the 5-in. crank-pin fit. As in the case of the main crank pin, the bearing is completed by a single cup 11 1/2 in. in outside diameter, on which bears the bronze-bushed eye of the side rod. The overall length of the bearing, including the end enclosures, is 4 7/8 in.

Although differing in detail, all the bearings have the same type closure. This consists of a split retaining ring which, when in place around the cup of the bearing, bears against a lateral shoulder or flange on the cup. To this ring is secured, by wire-lock machine screws, the steel closure which moves with the cup. This is sealed by a phosphor-bronze retaining ring set in a groove in the bearing cone and fitting against the inner surface of the end closure. In all cases, except at the outer end of the main crank-pin bearing, the retaining rings fit around the outside of the cups. In the latter case the ring is fitted inside the cup and the closure member, by an extension of its outer diameter, forms the collar to retain the rods in position.

Fig. 4. — The driving-journal bearing and housing mounted on the axle.

All crank pins are hollow bored, the main to a diameter of 3 1/2 in. and the others to a diameter of 3 in. This bore, closed at the ends, forms a reservoir for lubricating oil and contains the device for metering the oil to the bearing. This consists of a short metal cylinder, in the outer surface of which are grooves for felt rings and between these rings a circular cavity from which two passages 180° apart, drilled through the crank-pin wall, lead to a small annular groove cut in the inner circumference of one of the bearing cones. From this annular passage two drilled holes, 180° apart, but spaced 90° from the holes through the crank pin, conduct the oil into the space about the rollers.

Holes drilled through the sides of the grooves in the cylinder within the pin bore give the oil access to the felt rings and permit it to feed through these rings into the cavity between them. The amount which feeds through the felt rings

is determined by the hydraulic pressure to which they are subjected and this varies with the speed of rotation of the driving wheels. The feeding of the oil is thus automatically proportioned to the speed of the locomotive. As the oil enters the space about the rollers it is thrown to the inside of the cup by centrifugal force, where it accumulates about the rollers and overflows through passages in the cup which lead to the rod bearings. Thus, there are no oil holes in the rods. Rex fittings in the outer ends of the crank pins provide for the filling of the oil cavities inside the pins.

It is thus evident that the roller bearings float between the pins and the rods. In the case of the main pin, the bearing cup itself performs the double function of knuckle pin and crank pin in distributing the load from the main rod to the front and back drivers. The main crank pin itself is only subject to as much of the load as is transmitted to the main wheel. The length of the bearing on this pin has been determined by the necessity for locating the main rod according to present cylinder spacing rather than by the requirements of rod and pin design. Hence, the relatively large spacer between the front section of the side rod and the main rod and the 8 27/32 in. rear crank pin extension by which the bearing is separated from the face of the rear driving wheel.

Rods.

The rod design finally adopted was developed after an extensive study involving a long series of tests to determine the best distribution of metal to avoid high stress concentration. The form adopted is of I-section, tapering horizontally to relatively narrow bearings at the ends. The main rod, the body of which is 4 3/4 in. wide with 3/8 in. web thickness, is tapered to a width of 3 in. at the bearing. The side rods are 2 3/4 in. wide with 1/4-in. webs and taper to a width of 1 1/2 in. at the bearing. In the case of both side and main rods the metal about the bearings is formed in I-section by a process of drop forging developed to insure a smooth flow of metal about the bearing openings.

One of the most interesting parts of the installation is the crosshead. This consists essentially of three parts : the body, the pivot plates, and the shoe. The body of the crosshead is a forging, which serves to connect the piston rod with the wrist pin. Bosses about the wristpin opening on the sides of the crosshead serve as bearings for the pivot plates, which are free to rotate about them. Between the pivot plates is bolted the aluminum-alloy crosshead shoe design for the Pennsylvania type multiwear guide. Thus, neither inertia forces from the crosshead shoe nor pistonhead wear can produce bending moments in the piston rod.

The wrist pin is mounted in two specially designed Timken roller bearings,

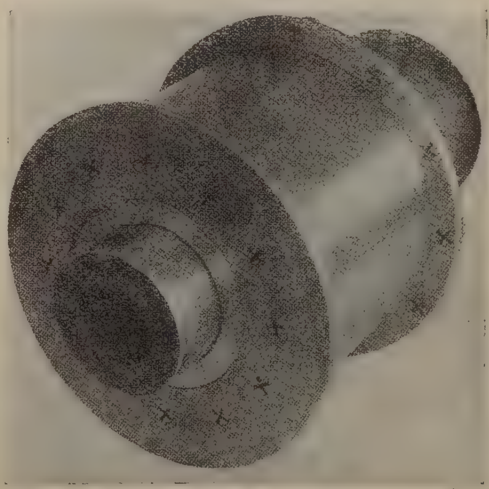


Fig. 5. — The Timken roller-bearing assembly on the main crank pin.

each consisting of a single set of rollers without retainers in a cone pressed in the crosshead. The inner race of the rollers is the wrist pin itself, which is pressed in the front end of the main rod. Like the crank pin, the wrist pin is hollow bored, to 2 1/2 in. diameter, and contains lubrication devices similar to those in the crank pin, one for each set of rollers. The inner end of the bearing is completely enclosed by a plate bolted to the crosshead. At the outer end where the end of the pin extends through for the union link a special raw hide seal is provided. The bushings of the pivot plates on the crossheads are 1/8 in. bronze strips fabricated similarly to those in the side and main rods.

Both the piston and piston rod are forgings. The rod, which is forged from cold-drawn Timken seamless tubing, is 3 in. in inside diameter and 4 1/2 in. in outside diameter. The shape of the piston conforms to the standard for the engine class, except for a substantial reduction in section and weight. Because of the thinner sections and higher strength of the steel the piston deflects within its yield point 2.8 times as much as a carbon steel piston of axle grade within its yield point. This is the equivalent of two pints more in water entraining capacity per cylinder before rupture of the piston will occur.

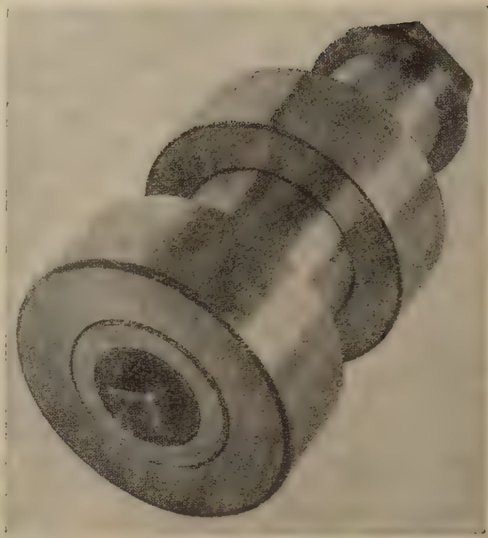


Fig. 7. — The roller bearings mounted on the crosshead pin.

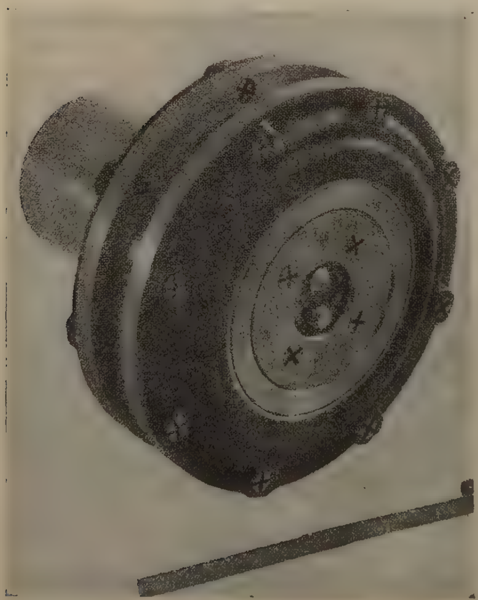


Fig. 6. — The roller-bearing assembly on the front and rear crank pins.

Indicative of the care with which the distribution of metal in the various parts has been studied is the crosshead key. At the edges where it bears against the ends of the keyway in the crosshead and the rod the key is 1 3/8 in. wide. The body, however, is forged down to a web thickness of 3/8 in. except where it bears directly against the keyways. Here it is increased to 3/4 in. to resist the shear. This key weighs 8 1/2 lb.

Axle bearings.

Locomotive No. 5371 is completely equipped with roller-bearing axles. The

engine truck is provided with the standard Timken engine truck boxes. The

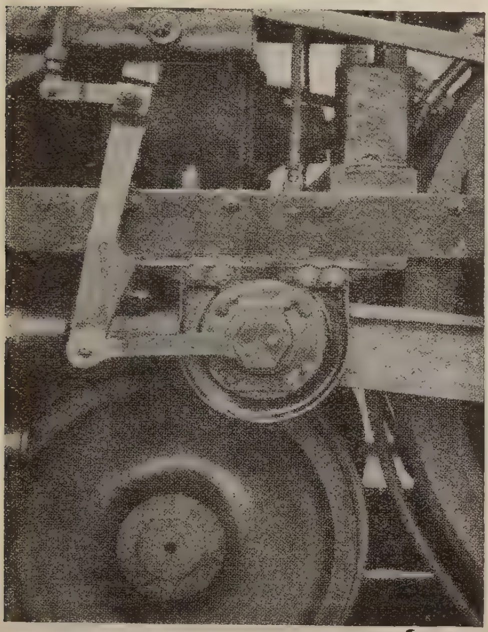


Fig. 8. — The crosshead, on which the shoe is pivoted.

driving and trailer boxes, however, were designed to replace the plain-bearing boxes for which the locomotive was originally designed, without major changes in the truck and frame construction.

In preparing the frame pedestals for the Timken driving boxes, the tapered sides of the pedestal jaws have been built up by welding, with wedge shaped fillers, and a hard bronze liner installed to provide a bearing face which is parallel to the shoe face of the jaw. This is also faced with a hard bronze liner. Like other Timken driving-axle installations, the bearings on each axle are mounted in a single box unit which, surrounding the axle, extends across the locomotive between the frames. Lateral movement of the axle and box unit is controlled by flanges inside the frame which bear against hardened steel facings welded to the inside of each pedestal leg. The bearing on each journal consists of two sets of Timken roller bearings. All axle journals are 10 3/4 in. in diameter. The pedestals are closed with the usual binders. The boxes are 17 1/2 in. in width over the housing liners, and 1/64 in. total clearance is allowed between these liners and the frame shoes.

The trailer housing is designed to fit the trailer truck without change either in the pedestal or in the springs. The bearing has two sets of rollers pressed on to a journal diameter of 6 1/2 in.

[621. 43 (62)]

Luxury rail travel over desert lines in Egypt.

Ten air-conditioned diesel cars put into service round Cairo and Alexandria.

(*Diesel Railway Traction*, Supplement to *The Railway Gazette*.)

At a cost of £ E. 7 585 per unit, the Egyptian State Railways ordered in July, 1934, ten 220/275 B.H.P. diesel-mechanical railcars from Ganz & Co. of Budapest, to a specification which was most stringent as regards the satisfactory performance of the vehicles in actual service, and which called for certain unusual fittings to meet the exigencies of the Egyptian climate.

The first five of these railcars have been delivered, and have undergone tests on various sections of the line. The illustration figure 1 shows one of the vehicles between Port Tewfik (Suez) and Pont Limoun (Cairo) on the occasion of a trial trip over the Suez direct line, when the 144.5 km. (90 miles) were covered in a net running time of 114 minutes, with a maximum speed of 105 km. (65.2 miles) per hour. It is anticipated that two regular railcar services in each direction daily will be inaugurated shortly over this route, and these diesel cars also will operate services over the following lines: Bab-el-Louk-Helwan, Cairo-Barrage (winter only), Alexandria-Hammam Luka, and Alexandria-Abu Qir (summer only).

Of the double-bogie type with one

Fig. 1. — One of the new Egyptian State Railways diesel cars on a trial run from Suez to Cairo.

driving and one carrying bogie, these Egyptian railcars are very similar in general design to the express cars of the Hungarian State Railways which maintain an international service between Budapest and Vienna. Being intended for solo operation, they are fitted with the lightest buffers and drawgear, and to avoid the necessity of turntables they have a driving compartment at each end of the semi-streamlined body. The designed top speed is 110 km. (68.3 miles) per hour, but during some preliminary trials in Hungary a speed of 117 km. (73 miles) per hour was reached, and a rate of 100 km. (62.1 miles)

per hour attained from rest in 3 min. 24 sec. on the level. Braking tests showed that the car could be stopped from a speed of 110 km. (68.3 miles) per hour in 500 m. (550 yards) within 30 seconds, the brakes being of the normal Westinghouse type with two blocks on each wheel. These standard-gauge cars were run on their own wheels from the maker's works at Budapest to Bremen, from which port they were shipped to Port Said in a semi-erected condition.

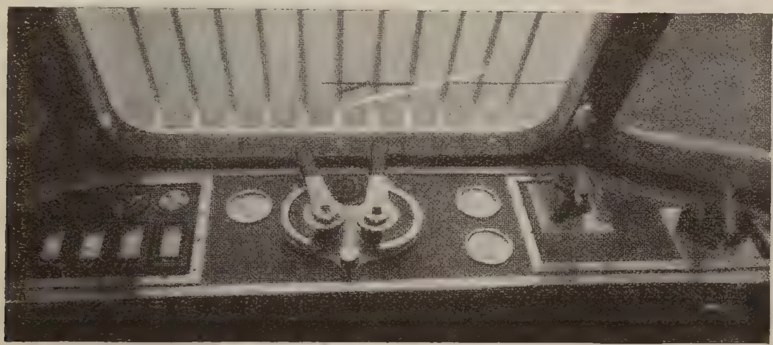


Fig. 2. — Looking down on the driving position.

Some of the cars have first and second class seats, and the remainder first and third class, the total in each case being 70. Lavatory and luggage accommodation is provided in both types. The weights of the railcars are as follow :

—	1st and 2nd	1st and 3rd
Tare weight, tonnes	36.8	35.6
Weight with supplies, but without passengers.	37.55	36.35
Weight complete with 70 passengers and luggage	42.5	41.25
Fuel capacity	340 kgr. (749 lb.).	
Water capacity	340 kgr. (749 lb.).	

Fig. 3. — End condenser for air-conditioner.

The tare weight is thus equivalent to 1 140 lb. per seat, and the B.H.P. per ton of tare (at the continuous engine rating of 220 B.H.P.) 6.1, taking an average for the two patterns of car.

Power unit and transmission.

Mounted directly on one bogie, the engine and five-speed gearbox are both of Ganz design and construction, and the layout of the complete unit can be seen in the accompanying detailed ar-

rangement drawings. The six-cylinder (170 mm. by 220 mm.) Ganz-Jendrassik engine develops a continuous output of 220 B.H.P. at 1 250 r.p.m. and a maximum of 275 B.H.P. at 1 450 r.p.m., and has a weight of approximately 20 lb. per B.H.P. on the continuous rating. The design of this type of engine has been described in past issues of the *Diesel Railway Traction Supplement*, and a cross-section of a 365/400 B.H.P. unit was reproduced in the issue of February 22, 1935. The engines of the Egyptian cars represent the latest practice, particularly as regards materials. The crankshaft is of nickel-chrome-molybdenum steel supported on seven bearings, and the pistons and crankcase are of light metal. A double-walled protective casing covers the top of the engine where it projects through the engine room floor, and provides heat and noise insulation. The combustion air is drawn in through the air-conditioned passenger compartments, thereby preventing the ingress of sand and dust, which are prevalent in the Egyptian atmosphere. The drive of the engine and railcar auxiliaries, including the air-conditioning plant, is shown in one of the drawings reproduced with this article.

The main clutch and the reversing gear are housed in a steel casing bolted directly to the engine crankcase. The main clutch is of the multiple-disc friction type with Ferodo linings. Of similar design to that illustrated in the issue of *Diesel Railway Traction* for July 12, 1935 (p. 89), the Ganz five-speed transmission has gear wheels of nickel-chrome steel in permanent mesh. The gears run in oil within a light-metal case, and gear-changing is effected by compressed air actuating servo-motors which are controlled from the driver's cabins. The controlling handle is the right of the two centre levers to be seen in figure 2; the left centre handle is the throttle control, the far right the Westinghouse brake driver's valve, and the middle right the reversing handle. Friction clutches are used also in the gearbox. The drive is led from the gearbox through cardan shafts with Hardy-Spicer flexible couplings to single bevels on each axle of the driving bogie. Torque rods take the driving thrust from the casing of each axle drive and transmit it to the frame. The engine and gearbox are supported on the bogie frame structure through the intermediary of rubber cushioning springs.

The bogies.

Although incorporated in a fast railcar, the bogies are of the non-bolster type, and the weight is carried wholly on eight triple-helical springs, mounted one on each side of the roller-bearing axleboxes. Although the engine is mounted in front of the pivot, it has been found possible to get the latter on the centre of the wheelbase, which, in the case of the driving bogie, extends to no less than 3.95 m. (12 ft. 11 in.), and in the carrying bogie to 3.50 m. (11 ft. 5 1/2 in.), the wheels in each case being of 920 mm. (36 in.) diameter. Side frames of the girder type (made up of top and bottom channels with welded side pieces) are used as the foundation, and the whole bogie frame structure is welded together to form a light yet rigid unit, the lightness being obtained partly by the use of electric welding and partly by reason of the 50-60 kgr./mm^2 (32/38 tons per sq. in.) chrome steel of which the various members are made. From the drawings it will be seen that everything possible has been done to reduce weight without impairing the rigidity of the structure. The unstressed portions of the bogie cross stretchers have been cut away, and steel castings have been used for such details as the spring brackets.

A special feature of the bogie is that the hemispherical pivot has no centre pin, and when the railcar is lifted com-

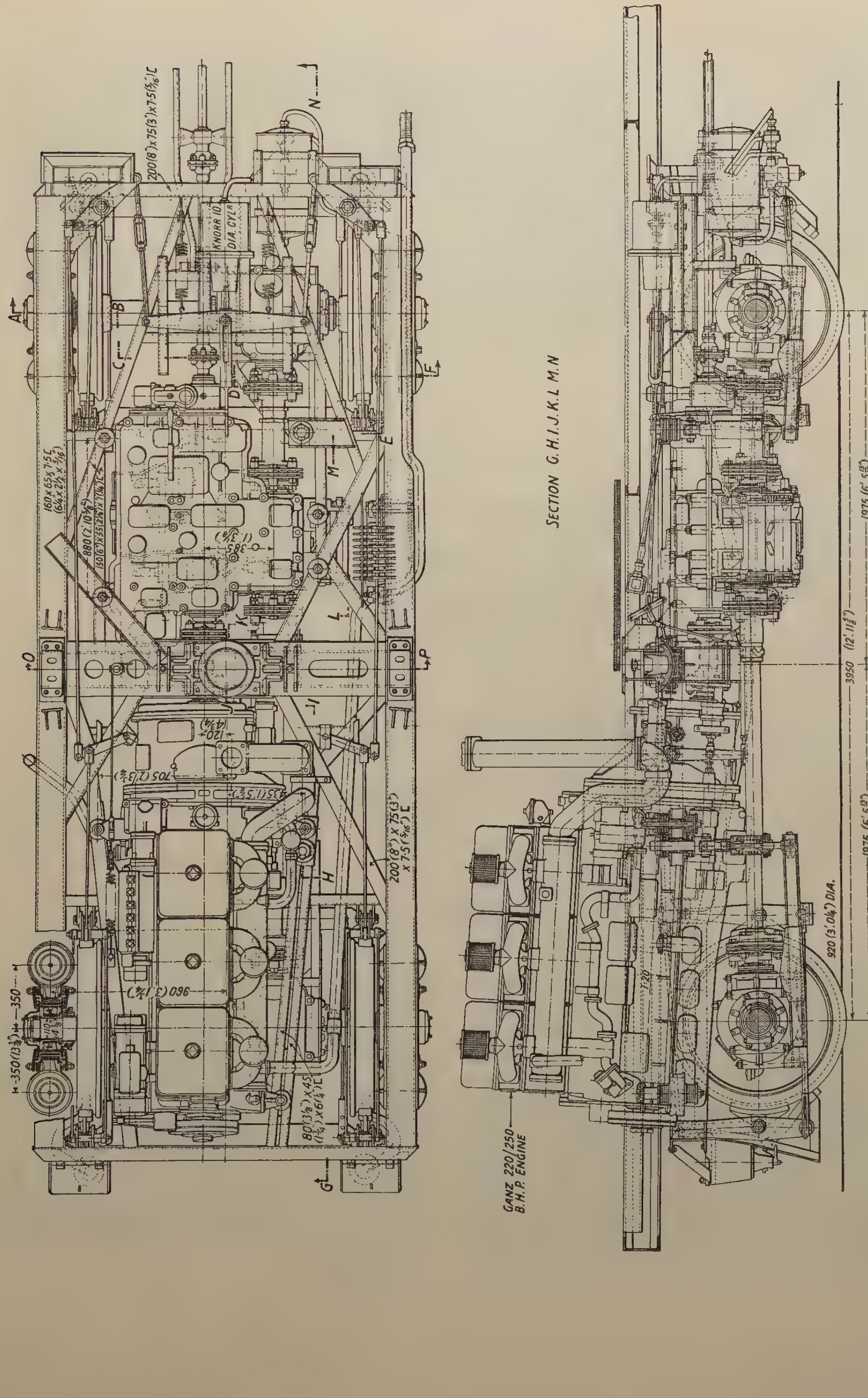
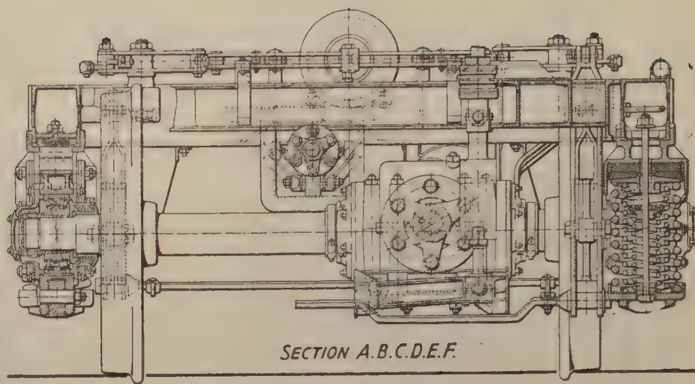
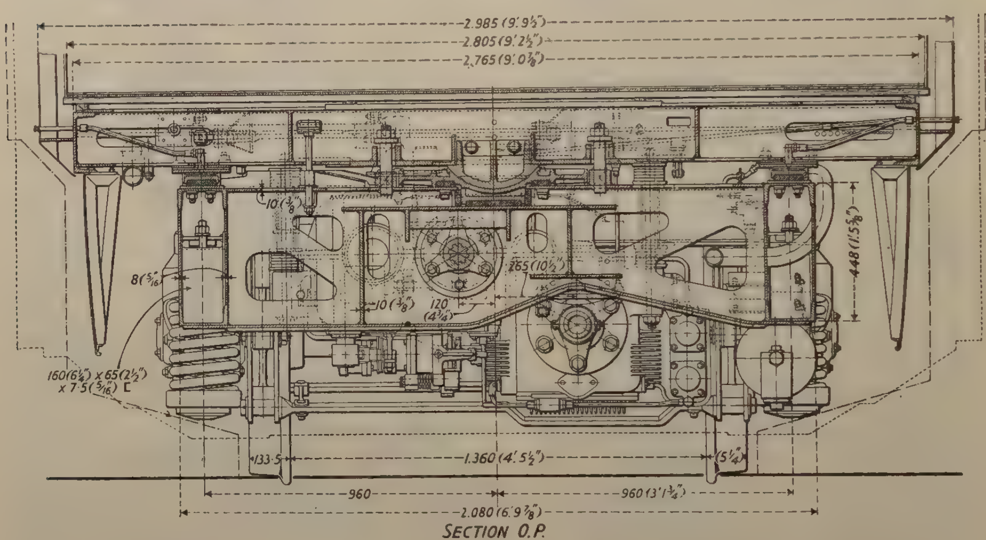


Fig. 4. — Longitudinal cross section and plan of driving bogie, Ganz 220-B.H.P. diesel-mechanical railcar for Egypt.

Fig. 5. — Cross sections of driving bogie of diesel-mechanical railcar of the Egyptian State Railways.





plete, the weight of the bogie is suspended on the washers of two pins located about one foot from the pivot centre on the transverse centre line. Flat side bearers are used and both the top and bottom halves have rubber cushions, a feature which has been used in other parts of the bogie, *e.g.*, above the helical bearing springs, and below the main pivot, and by this means the transmission to the passenger saloons of noise and vibrations arising from the track has been eliminated to a considerable extent. A 10-inch air brake cylinder of Knorr manufacture is mounted on each bogie, and by means of equalised levers applies two blocks to each wheel. Air sanding is applied to the outer sides of both sets of driving wheels, and is operated by compressed air taken from the Westinghouse brake system. Despite the large amount of power and transmission mechanism on the bogie, all the details are accessible.

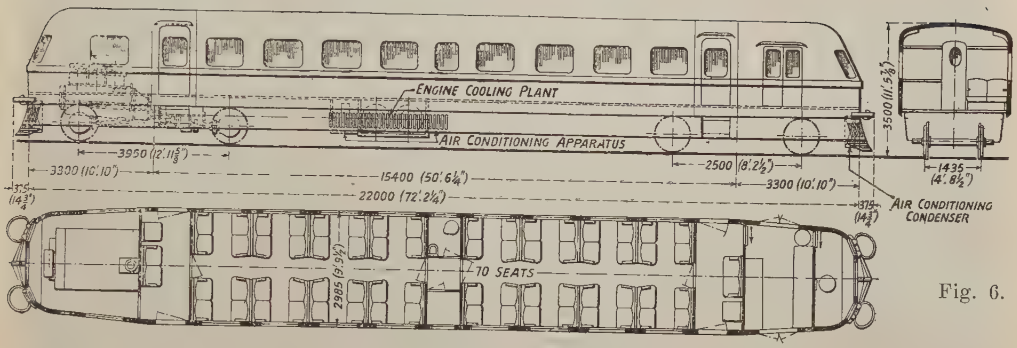
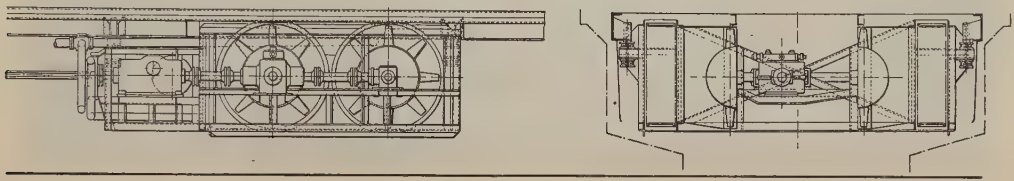
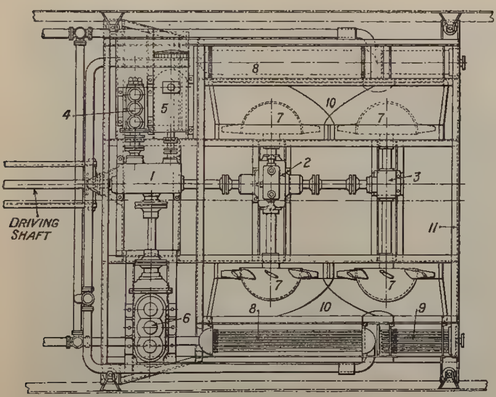
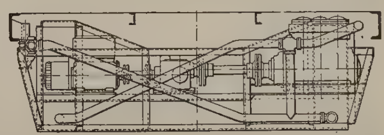


Fig. 6.







1. Gear box for auxiliary equipment.
2. Gear box for fan No. 1.
3. Gear box for fan No. 2.
4. Braking compressor.
5. Lighting dynamo.
6. Compressor of air conditioning plant.
7. Cooling fans.
8. Refrigerator for the oil engine.
9. Freon-condenser.
10. Casing of the fans.
11. Frame for auxiliary equipment.

Fig. 7. — Arrangement of the engine, railcar and air-conditioning auxiliaries on the Ganz railcars for Egypt.

The body.

Electric welding and chrome steel have been used also in the fabrication of the body framing. The steel side panels have an outside silver-grey varnish and an interior lining of Alfol in order to assist in keeping the passenger saloons cool, an object which is attained mainly by the provision of air-conditioning apparatus with auxiliaries driven directly by the main engine, and not by the more usual electrical means,

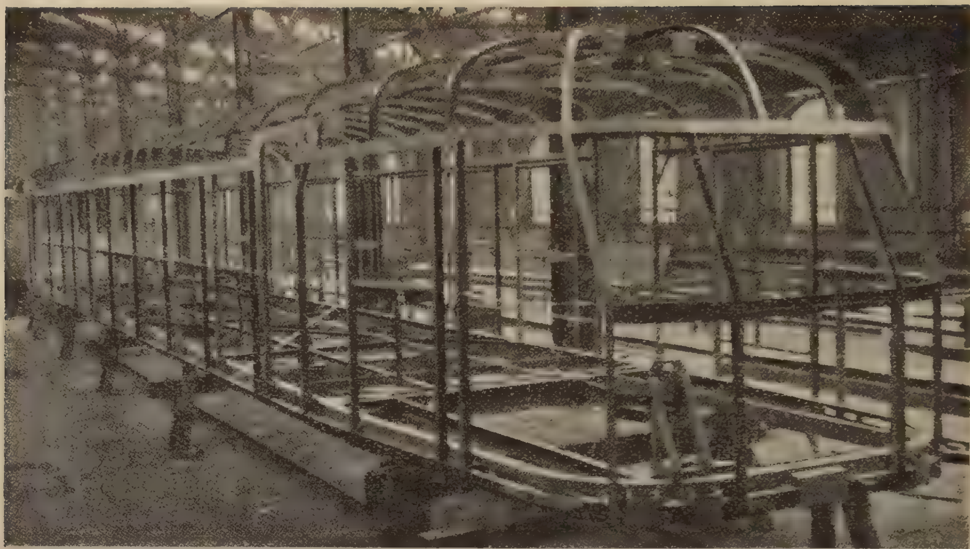


Fig. 8. — Welded body framing of high-tensile chrome-steel stampings. The length of the framing is 72 ft., and the width 9 ft. 6 in.

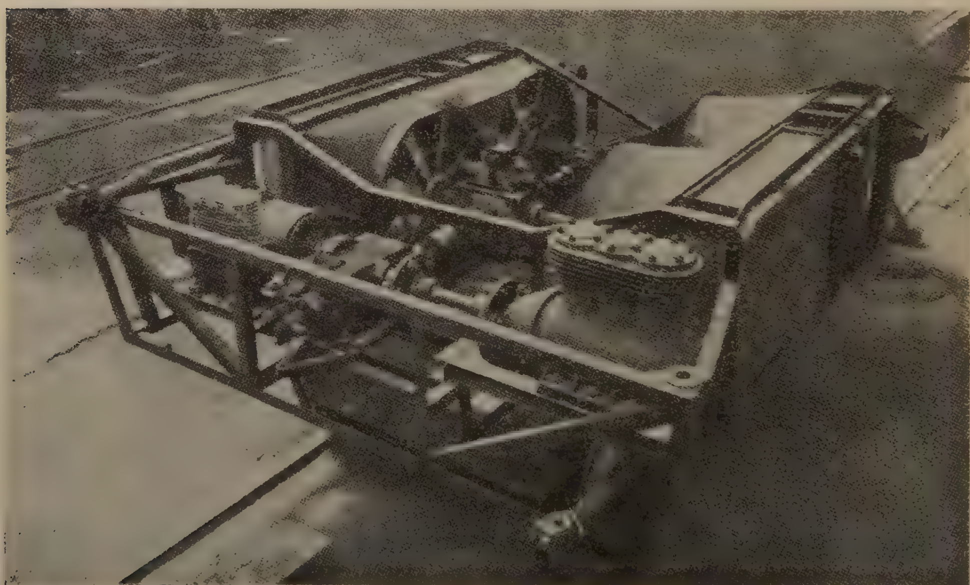


Fig. 9. — Arrangement of auxiliaries on subframe showing the Freon condenser for the air-conditioning apparatus at the end of the engine radiators, the two fans on each side being common to both. The air-conditioning compressor is in the right foreground, the auxiliaries gearbox in the middle foreground, and the brake compressor and lighting dynamo at the left.

Fig. 10. — Interior of first and second class railcar showing the inlet ducts for the reconditioned air below the ceiling, and in the floor the trapdoors for inspecting the auxiliary equipment.

with a consequent saving in weight of 1 1/2 to 2 tons. The operation of this Ganz air-conditioning system (which also cools the drinking water in the lavatory) is described in a separate article hereafter. The car is lighted electrically, and the current for this comes from a 24-volt battery of 360 amp./hr. capacity; this also provides the current for the main engine starting motors, of which there are two. The lighting dynamo, brake air compressor, engine cooling water fans, and air-conditioning auxiliaries are mounted on a sub-frame below the centre of the car.

The first and second class saloons are fitted with comfortable curved-back seats with single arm rests, and covered in leather. The wall panels and transverse partitions are of polished mahogany plywood, and the windows are of special glass, raised and lowered by means of balanced crank handles. Silk curtains are hung on the insides of the windows, and protection from the sun's rays is obtained by aluminium louvres. Parcel racks are carried along the side walls at cantrail level and immediately below the air inlet ducts; the air outlet ducts are at the bottoms of the side walls.

[621. 43 (.62) & 625. 234 (.62)]

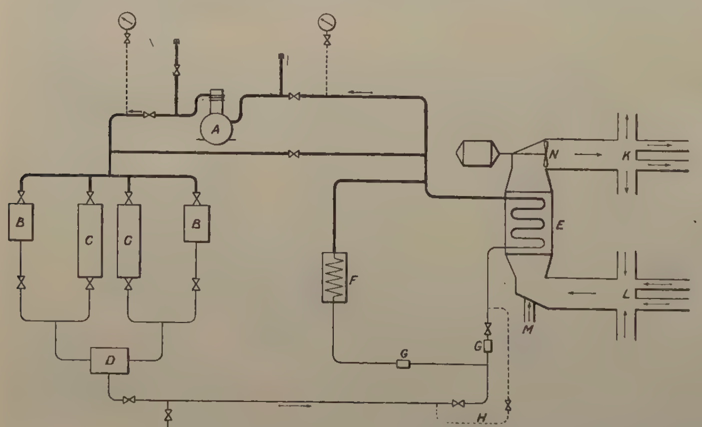
The Ganz air-conditioning system.

Equipment developed specially for railcars.

(*Diesel Railway Traction*, Supplement to *The Railway Gazette*.)

The ten diesel railcars now being delivered to the Egyptian State Railways, and described in the preceding article, have their external walls lagged with Alfol to prevent the ingress of solar heat, and each car carries a vapour-compression refrigeration plant, using Freon (difluor-dichlor-methane), as the working substance, to cool and de-humidify the air in the passenger compartments. The capacity of the plant is 14-16 000 calories an hour and with an external temperature of 35° C., it will cool down the car interior 6 or 7° C. in 20 to 25 minutes, when the car has a full complement of passengers. The temperature inside the car is related automatically to the temperature outside, the control being arranged to give a zero temperature difference when the ambient temperature is 20° to 22° C.

The principle of air-conditioning involves the use of a cooling agent which is compressed and then liquefied in a condenser, after which it is evaporated and picked up by the compressor to repeat the cycle. The heat necessary for the evaporation of the cooling agent is abstracted from the air circulated through the car by means of fans, the air itself being cooled in the process. During the cooling a great part of the



A. Compressor.
B. Front condensers.
C. Side condensers.
D. Freon tank.
E. Evaporator.
F. Drinkwater cooler.
G. Regulating valve.
H. Bypass.
K. Delivery pipe line.
L. Suction pipe line.
M. Drawing in of fresh air.
N. Circulation fan with electric motor.

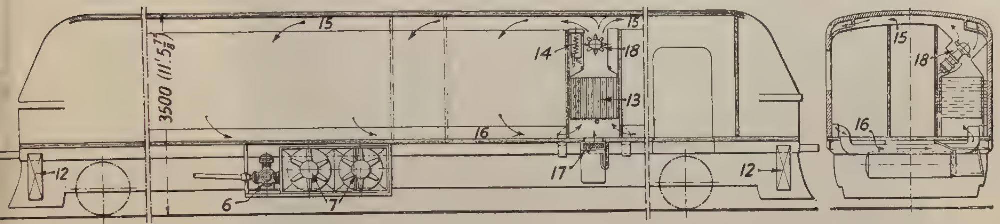
Fig. 1. — Diagram illustrating the principle and working cycle of Ganz air-conditioner.

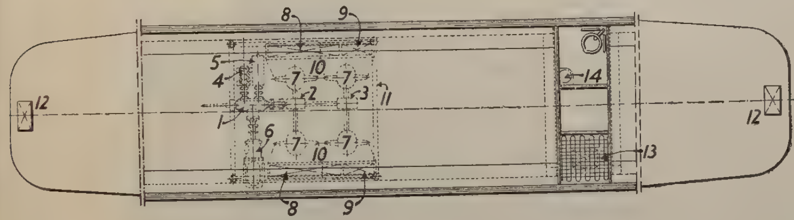
humidity of the used air is precipitated. The renewal of the air is effected by drawing in through suitable filters a small proportion of outside air.

As shown in figure 1, the air-conditioning equipment is conventional so far as the thermal cycle is concerned. In this diagram the thick black lines in-

dicate the passage of Freon in the vaporous, or mainly vaporous, condition, and the thin black lines indicate its passage in the liquid state. A high pressure prevails to the left of *A* round to *G* where throttling takes place. Beyond *G*, through *E* to *A* the pressure is lower. The evaporator, serving as an air-cooler, is installed in a special cabinet in the body of the railcar, and consists of a system of ribbed tubes through which the evaporating cooling agent flows. The circulating air is drawn over the coils of the evaporator by a fan and delivered through distributing ducts arranged along the sides of the passenger saloon ceilings. The used air is drawn off through ducts at the sides of the car floor.

Where the air-conditioning equipment



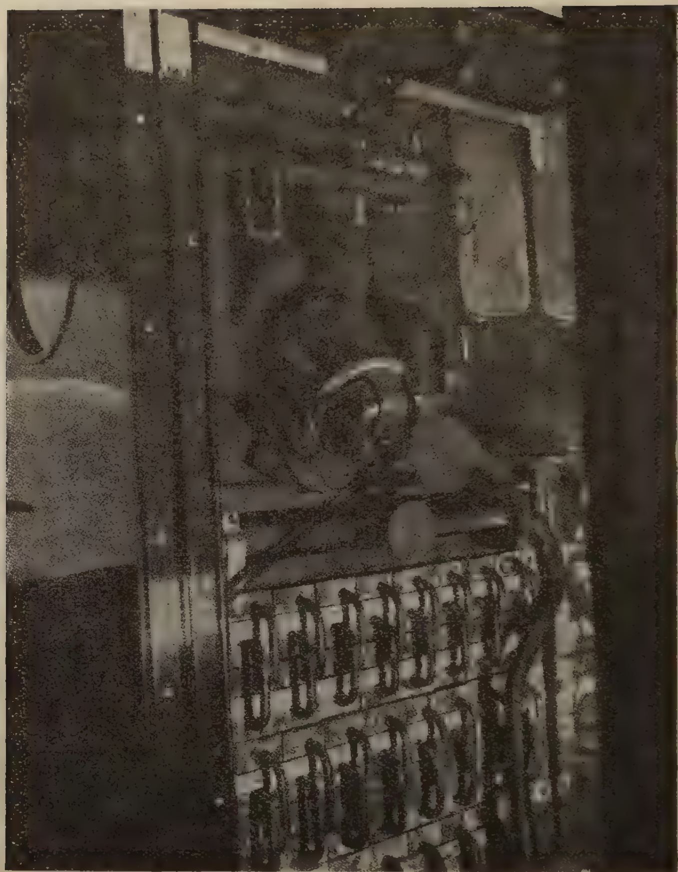


1. Gear box for auxiliary equipment.
2. Gear box for fan No. 1.
3. Gear box for fan No. 2.
4. Braking compressor.
5. Lighting dynamo.
9. Freon condenser.
6. Compressor of air-conditioning plant.
7. Cooling fans.
8. Radiator for main oil engive.
10. Casing of fans.
11. Frame for auxiliary equipment.
12. Front condensers.
13. Evaporator.
14. Drinkwater cooler.
15. Delivery pipe line.
16. Suction pipe line.
17. Drawing in of fresh air.
18. Circulation fan, with electric motor.

Fig. 2. — Layout of air-conditioning equipment and certain engine auxiliaries on the diesel railcars of the Egyptian State Railways.

in the Ganz cars differs from current practice is in the method of driving the compressor and the condenser fans. Instead of using electric power, which necessitates the use of heavy dynamos, motors, and storage batteries, and which offers the solitary advantage in trailer cars of being able to condition the air while the car is stationary, Ganz & Co. has developed a mechanical drive from the diesel engine. This drive has enabled a saving in weight to be made of about 60 %, compared with electrically-driven equipments, the air-conditioning plant weight being slightly under two tons in the Egyptian railcars. As the diesel engine can be kept running with the car standing, it is possible to maintain the auxiliary services, including the conditioning of the air, at all times.

From figure 2 it will be seen that the compressor and the condenser fans, with other auxiliaries, are connected through a gearbox and flexible cardan shaft to the gearbox and engine. The auxiliaries are mounted on a sub-frame attached through rubber blocks to the railcar underframe, and this arrangement was preferred to the alternative of carrying



Evaporator for air-conditioner mounted in cabinet in railcar body.

the auxiliaries on the bogies, as although this alternative would have obviated the need for a flexible cardan shaft drive, it would have introduced the much greater inconvenience of flexible pipe connections for high pressures. Moreover, it was prohibited by that lack of space which is a feature of most railcars.

MISCELLANEOUS INFORMATION.

[**621**. 335 (.494)]

1. — Light electric motor cars of the Swiss Federal Railways.

(*Bulletin Technique de la Suisse Romande.*)

Recently many foreign railway companies, with a view to giving a faster train service and to reducing the cost of passenger transport, have introduced light vehicles. By this means they were enabled to provide fast interurban services and also replace certain badly patronised heavy trains by a cheaper and quicker service.

In accordance with their policy of meeting the ever-increasing demands of the public, the Swiss Federal Railways in turn introduced, on the 11th May 1935, light electric rail motor cars. The experience obtained abroad was of no direct value to the Swiss railways. Railcars, in fact, have to be so much more powerful and stable on a difficult electrified system that the machines cannot be compared with those running in flat country.

For equal volumes of traffic, each time the frequency of the trains run is raised the length of the trains can be shortened. Hence the stops at station can be shortened to some extent as loading and unloading the train will be quicker. However, the section timings can only be shortened appreciably by raising the maximum speed and when the train has to stop frequently, by greater rates of acceleration and deceleration.

The Swiss lines have so many curves that the maximum speed can only be raised if the

Fig. 1. — One of the Swiss Federal Railways' new light rail motor cars.

weight of the vehicles is reduced. This reduction in weight is generally obtained at the expense of the power of the vehicle, and is therefore detrimental as regards its accelerative capacity. Relatively powerful motors ought therefore to be retained and the weight of the rest of the equipment be reduced as much as possible. Unfortunately this result can only be obtained at greater cost. On the basis of these technical and financial considerations, the maximum speed of the Swiss rail motor cars has been limited provisionally to 125 km. (77.5 miles) an hour.

The number of seats in these vehicles is 70; the units can run in either direction. They are 21.50 m. (70′ 6″) long, and weigh 32 t. (31.5 Engl. tons) empty. In view of their light construction, they cannot be formed in trains and are not fitted with draw- and buffing gear. The symmetrical body, of tubular construction, designed to give the minimum

Fig. 2. — Interior of the Swiss Federal Railways' new light rail motor cars.

air resistance, is carried on two four-wheeled bogies. For lightness, the unit is fitted with one pantograph only; no main switch is fitted, the current being cut off by lowering the pantograph. One bogie is fitted with two 300-H.P. single-phase traction motors. The braking is partly electric, the motors then generating continuous current which is absorbed by resistances. As the braking effort falls off as the speed rises, the second bogie is fitted with two electro-magnetic disc brakes. In addition, this bogie is fitted with the blocks of the compressed air brake applied to the wheels, and is so arranged that in case of emergency it can be applied either by the driver or by the passengers. The car is also fitted with a hand brake. The usual safety and automatic stop devices required for single-man operation are also provided in driver's compartments (figs. 1 and 2).

The driver is seated and controls the vehicle by a single wheel which when turned to the right brings in the motors progressively, whereas turned to the left it slows down the vehicle by increasing the braking (electric or electro-magnetic). The various instruments and gauges are arranged conveniently before him and include the reversing switch for changing the direction, the control current switches, and those for the lighting, heating, compressor, pantograph, etc... circuits, the air brake valve handle, sand gear lever, door operating gear, whistle control, etc.., and two signalling lights (one for the order to start, and the other for the safety device). When the driver leaves his seat, all the operating handles and levers are automatically locked.

Immediately behind the driver's compartments are the vestibules giving access to the vehicle and as the floor is only 72 cm. (2′ 4 3/8″), above rail level, instead of the usual 135 cm. (4′ 5 5/32″) the passengers get in and out very easily.

The seats are built of light steel tubes and are upholstered in leather; they are much more comfortable than the ordinary third-class benches. The builders, by giving attention to details, have been able to eliminate the noise and vibration frequently found in

this type of vehicle. Then too, as the body is carried on bogies at its outer ends and the compartments are arranged in between them the shocks and vibration experienced in running, which are so much in evidence in ordinary carriages, are much reduced.

The Swiss Federal Railways now have two such vehicles which are working on the Berne-Olten-Brougg, Berne-Bienne, Olten-Zofingue, and Berne-Lucerne lines on through and local services. This will make it possible to ascertain to what extent they are useful either for fast interurban services or to replace ordinary trains in periods of light traffic. Then too when more experience has been gained with them, the desirability of increasing the numbers can be decided.

It will then be possible to connect the Swiss towns by fast services and the value of this method will be appreciated when it is remembered that during its trials the rail motor car made the run from Geneva to Romanshorn in the following times : Geneva-Lausanne, 33 minutes; Lausanne-Berne, 61 minutes; Berne-Zurich, 1 hour, 24 minutes; Zurich-Winterthur, 21 minutes; Winterthur-Romanshorn, 34 minutes, or in all under four hours.

These Swiss Federal rail motor cars are a credit to the Swiss Industry and to the four Companies who collaborated in building them, Messrs. Oerlikon, Brown-Boveri (Baden), Sécheron (Geneva) and the Winterthur Locomotive Works.

D. BRD.

[621. 43 & 662]

2. — The testing of Diesel engines.

A special indicator developed to give accurate information required for the investigation of fuel characteristics.

(From *Diesel Railway Traction*, supplement to *The Railway Gazette*.)

The essential characteristics of a good fuel for the railway type of oil engine may be grouped generally under the three following headings :

1. Suitable physical characteristics.
2. Correct ignition quality.
3. Freedom from contamination.

Of these three, ignition quality is the most elusive and difficult to determine. Physical qualities can be examined in the laboratory and contamination is avoided by careful filtering and handling at every stage of the oil's journey from the refinery to the cylinder of the engine. Ignition quality, however, cannot be determined by any known laboratory test, but can only be satisfactorily examined by taking careful records of the behaviour of the fuel in the engine itself.

With the present types of diesel engine it is desirable to use only those fuels which start to burn quickly, for two important reasons, viz. :

1. The delay period between injection and ignition is reduced, thereby eliminating combustion shock due to the uncontrolled burning of the excess amount of fuel entering the cylinder prior to ignition.

2. Ease in starting under varying climatic conditions is obtained.

Recognition of the importance of obtaining fuels which have a short delay time between injection and the beginning of rapid burning has meant that special methods of fuel testing have had to be developed, so that phenomena occurring in times as short as one ten-thousandth of a second can be accurately observed. It is necessary, for example, to be able to determine precisely when the spray valve opens and to know whether it remains open or vibrates against its seating; the duration of opening must be determined, and also, in some cases, the nature of the pressures in the fuel supply pipes. The difficulty of the problem may be realised when it is mentioned that an atomiser may be lifted only eight to ten thousandths of an inch, the full lift taking less than a thousandth of a second and that, in addition, the valve may

partly or entirely reseat two, three or even more times during the next five- or six-thousandths of a second.

Pressure waves in the fuel supply pipe between the fuel pump and the atomiser may lead to pressure fluctuations at the atomiser end of the pipe, of about a 1 000 lb. per sq. inch in times as short as those associated with the atomiser valve movements themselves; pressures in the engine cylinder may rise by 200-300 lb. per sq. inch in almost equally short intervals. No mechanical indicator can give more than a very imperfect record of the changes which take place and it is for this reason that the Sunbury Electrical Indicator has been developed. This indicator was exhibited on the stand of Shell-Mex & B. P. Limited at the last Shipping & Machinery Exhibition, London.

How the indicator functions.

A special design of engine built for fuel testing purposes is shown in figure 1. It is fitted with means for accurate control of all operating conditions and can be used either for measuring ease of starting or for working tests under load. The compression ratio is adjustable to simulate different engine designs or to meet special experimental requirements. Many of the important mechanical details were developed by the Delft Laboratory of the Royal Dutch Shell Company.

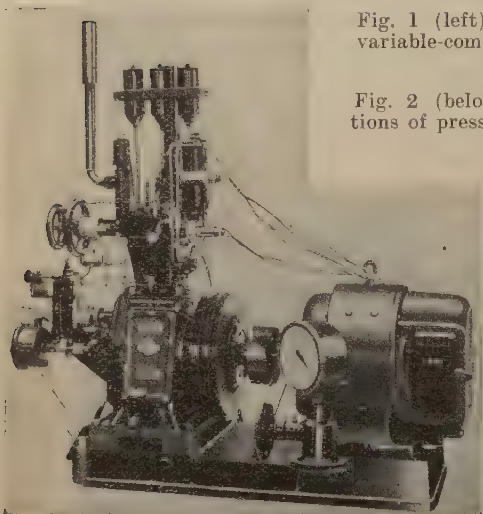


Fig. 1 (left). — The Co-operative Fuel Research diesel engine with variable-compression head which is used for the testing of different types of fuel.

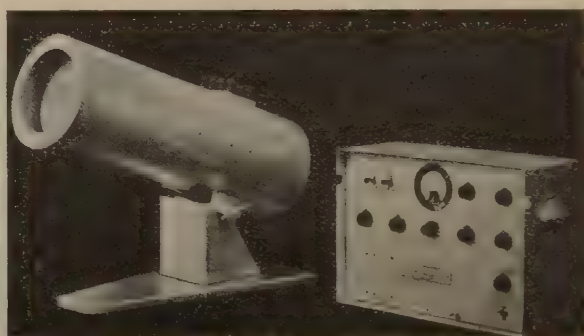
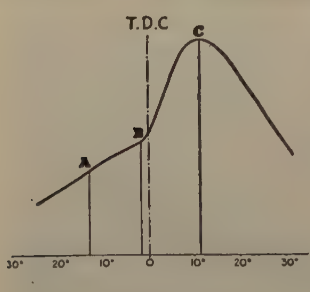


Fig. 2 (below). — Sunbury electrical indicator which gives indications of pressure-changing and similar phenomena occurring in a time as short as 0.0001 second.



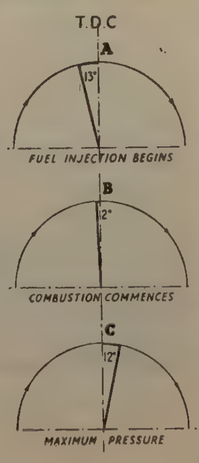


Fig. 3. — Diagram showing pressure changes in a cylinder on a crankshaft angle base.

An illustration of the indicating apparatus is given in figure 2. One of the essentials of the indicator is a cathode ray tube of the type developed for television purposes. Such a tube has the faculty of responding instantaneously to any electrical impulse applied to it and, unlike any mechanical device, is entirely free from inertia effects which may in-

troduce vibrations to mask effects actually taking place in an engine to which it may be applied.

When this cathode ray tube is in use, a brilliant spot of light appears on a fluorescent screen at the larger end and this spot is deflected by any voltages or magnetic forces applied to what are known as the deflecting plates of the tube. It is a comparatively simple matter to arrange a contact breaker driven from the engine crankshaft so that the spot of light travels across the screen along a horizontal line and so that it has always reached exactly the same place for any given position of the engine shaft. A ripple may be superimposed on this line which marks degrees of crank angle and also shows the top dead centre or any other reference position. For normal fuel testing purposes the rate of movement of the indicating spot is such that it travels about one tenth of an inch in a six-thousandth of a second, although either slower or faster rates are easily obtained with a simple control.

If a voltage is applied to a second pair of deflecting plates in the tube, the light will move vertically instead of horizontally and, if this separate voltage is one which varies with, say, engine cylinder pressures, the vertical travel will be proportional to the pressures. By applying both voltages at the same time, a diagram is produced which gives the change of pressure in the cylinder on a crankshaft degree base. Such a diagram is shown in figure 3.

Obtaining cylinder-prêssure changes.

Considering now the method of obtaining cylinder-pressure changes, many alternatives are available, but in all cases, there must be at least one mechanical member. Provided this is very stiff and is only required to move a very small distance compared with anything used in conjunction with a mechanical indicator, its high natural frequency is so far above the frequencies at which phenomena associated with engine and fuel behaviour occur, that the limitations due to its mechanical nature are entirely negligible.

In the Sunbury indicator a small and thick diaphragm is used, mounted in a stout fitting screwed into the engine cylinder. This diaphragm has a natural frequency of about 40 000 cycles per second, and, even at the highest cylinder pressures, has only to move about one two-thousandth of an inch. Its inertia effects are thus negligible and it is practically unaffected as regards behaviour by the temperatures reached in normal working. Its movements follow the pressure changes in the cylinder with such rapidity that its rate of movement at any instant is almost exactly the rate of change of pressure in the cylinder. Mounted near to this iron diaphragm, but at an appreciable distance from it in comparison with the maximum deflection, is a small electro-magnet around the pole of which is wound a few thousand turns of fine wire. Voltages are induced in this coil when the engine is running, which are very closely proportional to the rates of pressure change in the engine cylinder. These voltages are amplified in a special amplifier comparable in construction with a simple wireless receiver and applied to the cathode ray tube.

A unit similar in general principle is used in the fuel supply pipe to register fuel pressures and a diagram from this indicator is shown in figure 4. The fuel pressure starts

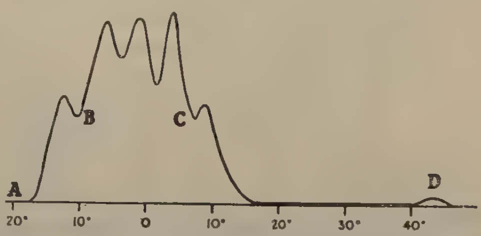


Fig. 4. — Diagram showing pressure changes in fuel pipe between pump and atomiser.

to rise at A when the fuel pump plunger over-runs the pump suction port and the rising pressure is checked at B by the opening of the spray valve. Following this is a series of pressure waves, the frequency of which is determined by the length of the fuel pipe, the

atomiser valve closing at C soon after the pump delivery valve closes. In the design of pump used on the engine on which these tests were made, there is a period during which a partial vacuum is created in the pump barrel. When this barrel is opened to the suction pipe the rush of fuel to fill the vacuum gives a blow to the delivery valve which lifts slightly and sends a pressure wave as shown at D through the fuel pipe to the spray valve. Normally, this will not reopen although it may do so in certain circumstances, producing a later and almost wasted injection of fuel.

[**621. 43 (.44) & 621. 8 (.44)**]

3. — Transmissions for diesel locomotives and railcars.

The A. L. M. gearbox,

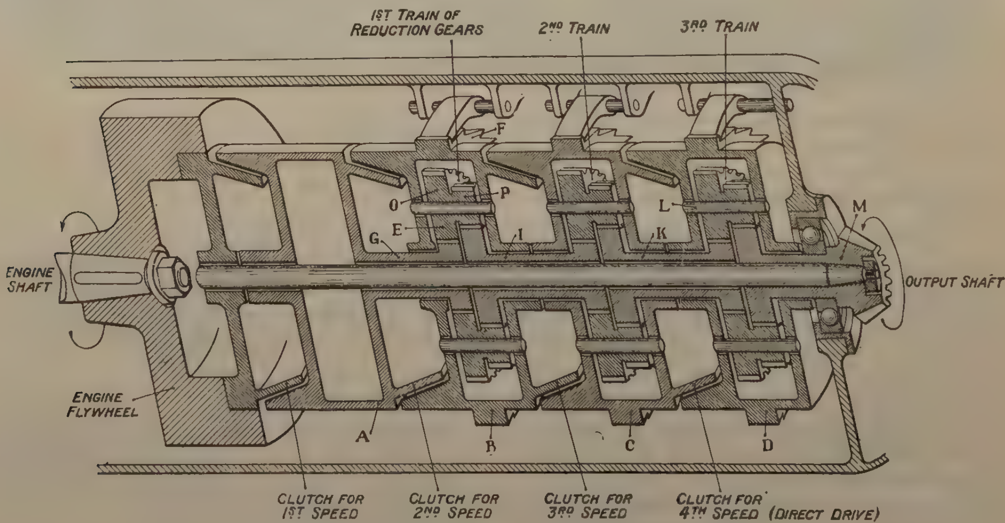
by STUART MIALL.

(*Diesel Railway Traction*, Supplement to *The Railway Gazette*.)

The illustration accompanying this article portrays in diagrammatic form a four-speed gearbox of French origin. From what follows it will be apparent that the box, which is a product of the Société de Construction d'Appareils de Levage, 78, Rue Vitruve, Paris, could easily be elaborated to give five, six, seven, or any other number of speeds.

As shown, the gearbox consists of four elements *A*, *B*, *C*, *D*, corresponding to speeds 1, 2, 3, 4 respectively. Each element has a clutch capable of transmitting the full-load torque of the engine, while elements *B*, *C*, and *D* have in addition a train of gears such as *E* for speed reduction, and a ratchet wheel such as *F*. The last named is for preventing rotation of the casing of the element in a direction opposite to that of the engine, and for transferring the reaction produced by the reduction gears, through pawls, to the stationary framework of the gearbox. In magnitude this reaction is equal to the difference between the tooth pressures of wheels *O* and *P*, referred to the radius at which the pawl acts on the ratchet. The direction of this reaction is backwards, *i.e.*, clockwise if viewed from the right.

The central shaft carries at its extremity



Diagrammatic arrangement of the A. L. M., or Applevage, gearbox.

the output bevel M, and it turns freely inside all the elements. The sleeves I and K, with two pinions each, are free on the central shaft, and in the casings through which they pass, and they transmit the drive from element to element, *i.e.*, from B to C and C to D.

Method of operation.

In the neutral position the four clutches are disengaged but clutch number 1 is engaged for first speed, making element A solid with the engine shaft. Sunwheel G, forming part of element A, engages the first reduction train which, through the sleeve I, is connected with the second train, and this in turn is connected through sleeve K with the third train. This last train actuates the output bevel M, and if it be supposed that each reduction train has a ratio of 1.5 to 1, the total first speed reduction will be $1.5 \times 1.5 \times 1.5 = 3.375$ to 1.

For second speed clutch 2 is engaged (clutch 1 remaining engaged). Casing B is in this way made solid with casing A and with the engine shaft, and because the spindle L now revolves at the same speed as G, the gears O and P of the first reduction train can no longer turn about their own common axis, but must serve simply as a claw for dragging round the central sleeve I at engine speed. The new ratio of reduction is $1.5 \times 1.5 = 2.25$ to 1.

Clutch 3 is engaged for third speed, clutches 2 and 1 remaining engaged. Casing C then becomes solid with casing B, casing A, and the engine shaft, and sleeve K is forced to revolve at engine speed. Under the new conditions the third reduction train operates alone and the total ratio of reduction is 1.5 to 1.

Clutch 4 is engaged for fourth speed, clutches 3, 2 and 1 remaining engaged. Direct drive is now established, since M is forced to revolve at engine speed. With all four clutches engaged, elements A, B, C, D, and the central shaft carrying M, rotate *en bloc*, and the three ratchet wheels are carried round under their three pawls. The latter are all under load during the operation of first speed. During second speed operation the pawls of D and C are under load and in third speed only the pawl of D is under load.

It should be mentioned again here that the ratchets and pawls shown in the illustration are purely diagrammatic, their place being taken in practice by freewheels, self-wrapping band brakes, or any other suitable devices which are able to resist a torque in one direction without giving rise to unbalanced lateral pressures on the central shaft. A single pawl would obviously tend to promote bending of this shaft .

Except in fourth speed, when the bevel M is solidly connected to the engine shaft, the A. L. M. gearbox gives a freewheel action, for, if the output bevel M, which is connected directly with the driving wheels of the vehicle, be overdriven by these wheels, the reactions on the spindles of the reduction train planet wheels (*e.g.*, on spindle L) are reversed in direction, so that the casings not clutched to the engine shaft, and normally at rest, are urged in the same direction of rotation as the engine. The pawls permit motion in this direction.

Advantages claimed.

Many advantages are claimed for the A.L.M. box and those which follow need no proof other than this description affords.

(1) The gears are always engaged, being of the constant mesh variety.

(2) While changing up from one speed to the next the propulsive effort is maintained This is an important advantage.

(3) A freewheel effect is secured in all speeds except the fourth or last one, so that when the vehicle is running with top or any other gear engaged it is possible to change suddenly into any lower gear, or into neutral, without changing the speed of the engine. The engine can accelerate at its own rate, or, if it be governed, continue to run at the original speed. With the engine governed to run at a fixed speed the vehicle will coast or freewheel after a change into a lower gear, and its speed will decrease until it reaches that at which the engine can again take up the drive.

(4) The energy absorbed in clutch slip and converted into heat is divided between as ma-

ny clutches as there are gears and so also is the wear. Each clutch slips only for the acceleration from one speed to the next.

(5) For a given power to be transmitted the second, third and remaining elements can be indentical in construction. The element of the first speed only differs in not having a reduction gear.

(6) It is possible to obtain a large number of speeds from a given box by adding to the number of elements in cascade. The total reduction ratio R of a box so composed would be the reduction ratio r of one element raised to the power n-1, where n is the total number of speeds. Thus $R = r^{n-1}$. With identical elements the gearbox ratios form a geometrical progression, being r^{n-1}, r^{n-2}, r^{n-3},... r^3, r^2, r and 1 to 1.

(7) It is a very simple matter to arrange for the remote control of the A.L.M. box, the operation being manual, electric, or pneumatic. It is also a simple matter to make the operation quite automatic, leaving the driver with only the engine throttle to manipulate.

NEW BOOKS AND PUBLICATIONS.

[656]

PIRATH (Dr.-Ing., Professor Carl). — **Konjunktur und Luftverkehr** (*Influence of the economic position on air traffic*). — New set of publications of the Institution of Scientific Research into Aerial Navigation, of the Stuttgart Higher Technical School. — A pamphlet (10 1/2 × 8 inches) of 58 pages, with 32 figures in the text. — 1935, Berlin. Published by the Verkehrswissenschaftliche Lehrmittelgesellschaft, m. b. H., bei der Deutschen Reichsbahn, 1, Potsdamer Platz. (Preis : 4.50 Rm.)

The author has endeavoured in this study to examine how far air traffic is affected by the fluctuation in the general world economic position, and in the principal countries concerned. As a supplementary research, he has endeavoured to show to what extent the Air Navigation Companies have improved their financial balance sheets.

The statistics used are those for the years 1927 to 1933. The beginning of this period coincides with the organisation, after many tentative efforts, of public services by the Airway Companies. After the 1929 peak, there was a marked drop in 1932, followed by some revival in 1933. However, comparison is made difficult as the air lines have continued to improve their capacity by rearranging their routes and timetables.

After an attempt to show the financial growth during the period considered by various indices, the author gives, with comments, the statistics of the increase in capacity of aircraft. His conclusion is that air traffic has suffered little from the crisis and that in the case of certain kinds of goods, it has even benefited from the particular circumstances arising from the crisis. The passenger traffic, on its side, seems to have been more intense during the depression.

The author compares the reduction in the rates with those granted by the railways, and endeavours to show the consequences.

In a special chapter the fixed expenditure and the direct expenditure per unit of traffic are dealt with. The author shows the value of the national subsidies, and endeavours to indicate the improvement in the financial results which would result from a more intensive use of the available equipment, and from further reductions in expenditure, to be added to those effected in the working costs.

E. M.

[385. (09 (.43)]

V. D. I.—ZEITSCHRIFT DES VEREINES DEUTSCHER INGENIEURE (*Bulletin of the Union of German Engineers*). — Special number of the *Zeitschrift* of the 12th October 1935. — **Eisenbahntechnik : Zum hundertjahrigen Bestehen der Deutschen Eisenbahnen** (*Railway technics : Commemoration of the centenary of the German Railways*). — A pamphlet (11 3/4 × 8 1/4 inches) of 59 pages with many illustrations. — 1935, Berlin, V. D. I. Zeitschrift, Hermann-Göring Strasse, 27.

The *Zeitschrift des Vereines Deutscher Ingenieure*, on the occasion of the centenary of the German Railways, published a special number, most of the articles in which were devoted to railway questions of present-day interest. In the preface, Dr. Dorpmüller, General Manager of the Reichsbahn, after referring to the creative work of the German railway pioneers, stresses the great influence

German engineers and inventors have had on the development of railway practice.

The first article is the reproduction of a very interesting lecture given by Dr. *Rémy*, on the guiding principles which successively governed the growth of railways in Germany. He examines in turn the economic, technical, scientific, social, and military aspects of this development, and then analyses the new policy required to meet road competition : higher speed, greater comfort and safety, relocation of lines, improved permanent way and structures, etc...

The pamphlet then includes a series of articles on subjects of present or future interest, by leading officials of the Reichsbahn or well known industrialists.

Dr. *Nordmann* gives particulars of tests of streamlined locomotives and in particular the new 05 type locomotive; Messrs. *Fuchs* and *Grassel* describe in detail the new 1 400-H.P. diesel locomotive of the Reichsbahn, fitted with Voith-Föttinger hydraulic transmission.

Herr *Ganzenmüller*, in an article on electric traction, gives a short review of the development of electric locomotives, followed by a description of the three main types of electric locomotives of the Reichsbahn. He also gives particulars of the new electric railcars.

The latest applications of welding in railway work is dealt with in several articles : by Messrs. *Schinke* for welded wagons, *Boden* for light passenger vehicles, and *Dörnen* for bridges carrying railway lines.

Herr *Blum* describes the latest improvements in station layouts, his article being a supplement to that in the *Zeitschrift*, in 1931. Herr *Rechel* gives particulars of improvements in high-speed shoe brakes on passenger vehicles; Herr *Gottschalk* of braking devices in marshalling yards: Fröhlich and Jordan mechanical brakes, magnetic brakes, etc... Herr *Hartmann* deals with the standardisation of points and crossings, and improved designs to meet present conditions; Herr *Schächterle* with the use of wood in railway work; Herr *Culemeyer* with the employment of road motor cars by the Reichsbahn; Messrs. *Ernst* and *Wolff* with bridges on motor roads, and finally Herr *Emmelius* with the organisation of the Reichsbahn purchasing department.

This publication ought to be brought to the notice of railway men as it provides much interesting information on many questions with which they are preoccupied at the present time.

A. C.

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